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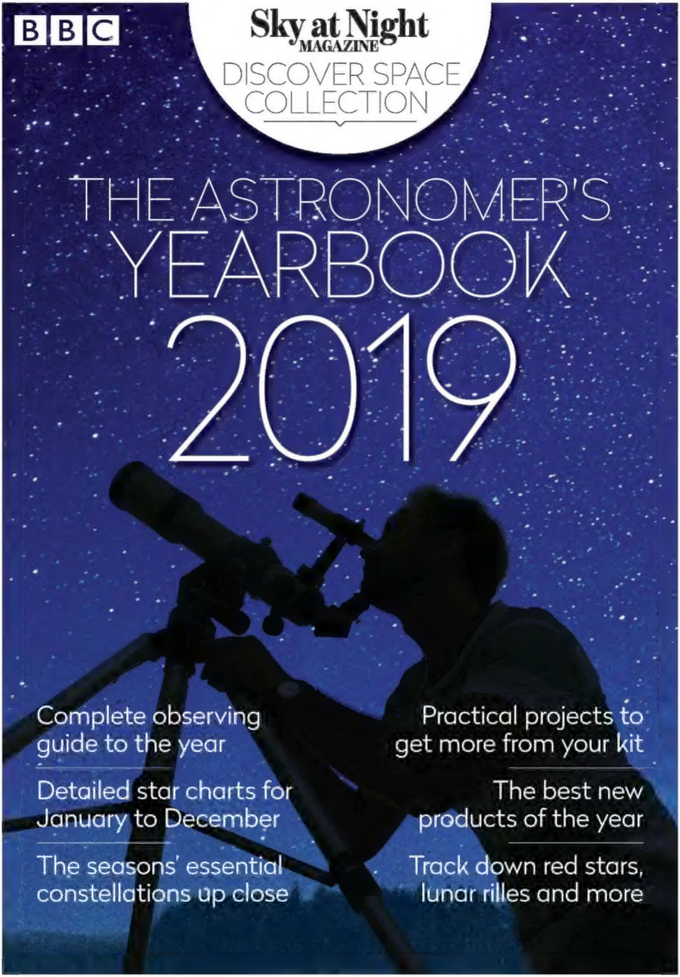
Sky at Night MAGAZINE

DISCOVER SPACE COLLECTION

THE ASTRONOMER'S YEARBOOK 2019



Complete observing guide to the year

Detailed star charts for January to December

The seasons' essential constellations up close

Practical projects to get more from your kit

The best new products of the year

Track down red stars, lunar rilles and more

IMMEDIATE MEDIA Co

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Welcome

Gaze up on a clear night and wonder awaits. Planets, stars, nebulae, constellations, galaxies, meteor showers... all waiting to be discovered.

Whether it's the sparkling spectacles of crisp autumn and winter evenings, or the glorious displays of a spring or summer night sky, we've got you covered.

Inside this Yearbook you'll find guides and star charts for every month of the year – when and where to find the finest sights in the ever-changing view above our heads.

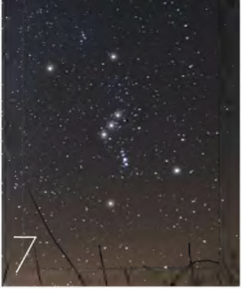
It's not just a matter of finding them, of course. The real reward is in understanding and appreciating what you're seeing – and this guide will help you do that. Top astronomy experts share their tips, not just on spotting well-known superstars of the skies, but on lesser-known but enchanting targets too. We've also set some challenges to help you hone your stargazing skills – give them a go and see how you get on.

All you need to spot many of the marvels on offer are your eyes, but things get really exciting when you add in some magnification, even if it's just a good pair of binoculars. Or, if you're in the market for some top-end kit, you'll find reviews and advice on equipment here too. There's also some superb astrophotography that's sure to whet your appetite, whether you're just starting out with a DSLR or itching to see what your CCD setup can achieve.

While there's plenty to keep you busy at night, we've got your daytimes covered too with our step-by-step DIY guides to making your own astronomy accessories.

With this Yearbook you'll know what to look forward to and what not to miss in 2019. Enjoy!

Chris Bramley, Editor


7


100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Northern Coalsack
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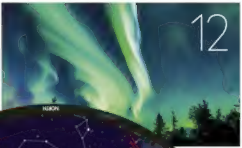
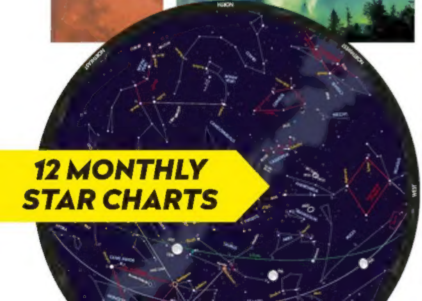
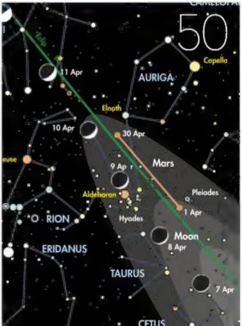
Cr 419
Berkeley 86
M29
NGC 6888
Basel 6
IC 4996
NGC 6883
NGC 6871
Biurakan 2
Gienah
Cygnus Rift
76


33


72


12


12 MONTHLY
STAR CHARTS


50
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11 Apr
AURIGA
Elnath
10 Apr
30 Apr
Mars
9 Apr
Aldebaran
Pleiades
1 Apr
Hyades
ORION
Moon
8 Apr
ERIDANUS
TAURUS
7 Apr
CETUS

Contents

Month by month guide

Seasonal constellations

Challenge yourself

Features

Reviews: best of 2018

How to

Miscellaneous

The winter constellation Orion forms one of the most famous and easily recognisable patterns in the night sky

Capturing THE HUNTER

The familiar winter constellation of Orion holds many surprises for imagers who want to delve a little deeper, says **Will Gater**

There are few constellations that grab the attention quite like that icon of the winter heavens, Orion. The glittering bright stars, the instantly recognisable 'belt' and the many glowing nebulae scattered within the Hunter's boundaries all make Orion a wonder to behold on a frosty, dark night. But the constellation is also a rich hunting ground for astrophotographers seeking captivating targets of many kinds. In this article we're going to explore some of the different ways Orion's splendours can be captured on camera, from a simple nightscape that conveys the naked-eye view to advanced CCD imaging techniques that can reveal the constellation's extraordinary deep-sky features. And hopefully, by the end of this piece, you'll agree with us that no matter how many times you catch sight of the Hunter, you'll always find something new to inspire you and test your astrophotography skills. ▸

ABOUT THE WRITER
Will Gater is an astronomy journalist, author and presenter. Follow him on Twitter at @willgater or visit willgater.com

The Hunter in his element

Orion's position near the celestial equator makes it easy to incorporate some landscape into your shots

Silhouetted treetops, city skylines or mountain peaks help contextualise Orion's position

EXPERIENCE LEVEL Beginner to intermediate

WHAT YOU'LL NEED A DSLR or bridge camera and a sturdy photographic tripod. A wide kit lens (of the kind that comes with most DSLRs) will be perfectly sufficient. More experienced astrophotographers may also want to use a portable tracking mount to capture longer exposures.

There's something tremendously evocative about glimpsing the bright stars of Orion over a wintery landscape – or towards the end of the autumn months, just as the nights start to get longer and colder – so in this first part we're going to look at how to shoot a 'nightscape' that attempts to capture some of that magic.

STEP 1 Make a conceptual plan

Thinking about the emotions you want to convey or elicit with your shot can help you to plan a powerful picture, and it'll inform every stage of the photographic process. For example, if you wanted to evoke the harsh iciness of winter observing you might shoot Orion over an isolated, leafless tree in a barren landscape, and process the image in such a way as to create a hard contrast between land and sky.

STEP 2 Select your focal length or a prime lens

Once you've thought about what atmosphere you want to capture with your image, you can select the focal length you'll be shooting at. A typical kit lens set to around 24mm, or an equivalent prime lens, provides a wide field of view for Orion on a camera's sensor, allowing you to fit in the brighter central stars and the Hunter's fainter outlying 'arms'.

STEP 3 Focus the view

Next, focus the view. Some cameras have a live preview function that can be zoomed onto a suitable star, giving you instant feedback as you make slight focusing adjustments. With Orion there's no shortage of bright stars that can be used for this. Repeat the process a few times – checking that the star is as small as possible – so you're certain the image is as sharp as it can be.

STEP 4 Compose with the landscape and sky conditions

To compose your nightscape you can take short, very high ISO test exposures to show you the balance and positioning of foreground and sky, and any structures or landscape features in frame. Try to use the foreground – trees, buildings, etc – to lead the viewer's eye toward Orion. Sometimes clouds can be used as a framing device too, and thin cloud can even 'bloat' and enhance the colours of bright stars.

STEP 5 Set the exposure length, aperture and ISO

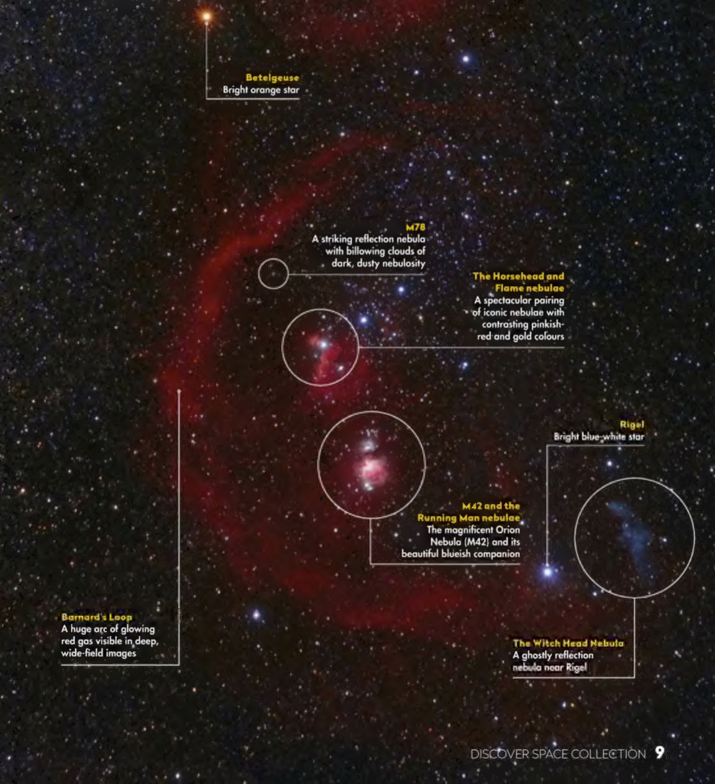
When shooting, keep the lens aperture wide open (lowest f-stop), though some lenses will perform better when reduced a few stops. Experiment with the ISO and exposure length until you're happy with the look. You may need to use an exposure that very slightly trails the stars in order to define the foreground.

STEP 6 Process your image

When processing nightscapes, reducing the noise in the image and bringing out foreground detail are the main challenges. As long as you shoot in RAW format, modern image-processing software is well-equipped to handle these tasks. In Photoshop or GIMP you can correct the colour balance, and use the 'Curves' tool to bring out star fields and improve overall contrast and definition. ▸

Orion overview

Where to find some of the constellation's best imaging targets



Far and WIDE

Reveal the hidden delights lurking within Orion with the help of long-exposure, wide-field imaging

EXPERIENCE LEVEL Intermediate
WHAT YOU'LL NEED A DSLR, a tracking mount and either a relatively long focal length camera lens (between 100 and 300mm focal length on a full-format DSLR) or a short focal length refractor. You could use a CCD camera, but the field of view produced by your setup will need to be at least 5° across or you'll need to mosaic.

One of the things that makes Orion so attractive for astrophotography is the diversity of deep-sky objects within its borders, from pinkish-red star-forming regions to blue-tinted reflection nebulae.

The proximity of these targets to one another means that long-exposure wide-field imaging of Orion can produce some spectacular compositions. Not only do such wide-field images show the positions of objects such as the Orion and Horsehead nebulae in relation to one another, but they can also reveal the rarely seen fainter surroundings of objects that are usually given the 'close-up' treatment, such as the aforementioned nebulae.

A DSLR with a long focal length lens and mounted on some form of equatorial tracking mount is probably the simplest setup with which to get started in wide-field imaging. Unlike most deep-sky imaging, wide-field deep-sky astrophotography generally doesn't require autoguiding, as it's possible to capture good data with unguided sub-exposures of just a minute or two.

With fast prime lenses and those relatively short exposure lengths, you may be surprised at how easily you can pick up some of Orion's most recognisable deep-sky objects. For the best results, capture multiple sub-exposures (as well as dark frames and flat fields) and then calibrate and stack them using software such as the free DeepSkyStacker, before final enhancements in your preferred image-processing software.

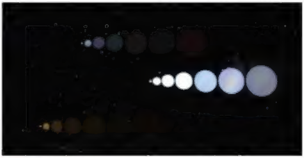

Wide-field imaging can reveal the Orion Nebula (M42) as hanging beneath Orion's Belt

Colourful captures

With the right setup, you can show that Orion is more than just white stars against a black background

EXPERIENCE LEVEL Beginner
WHAT YOU'LL NEED A basic DSLR or bridge camera fitted with a lens that allows manual focusing (some compact digital cameras will also work, depending on the lens/focusing mechanism they use). You'll also need a photographic tripod and your camera will need to be able to take exposures of a few seconds.

The colour variation of Orion's bright stars is one of the most captivating things about the constellation, yet it can be tricky to capture these wonderful hues as the chromatic aberration in some camera lenses overwhelms the true star colour. One method for showing the tints of stars such as Betelgeuse, Rigel and W Orionis is to manually defocus the image. It's a technique that was made famous by the renowned astrophotographer David Malin many years ago. You can use this method with a wide lens (or a fast long lens) on a static tripod, as long as you use short exposures – a second or so in the case of a longer lens. All you do is frame the star (or constellation), defocus the lens a little by hand and capture an exposure, usually at a mid-to-high level ISO setting. In the two composite images below we focused on Betelgeuse and Rigel. We captured a number of exposures and in between each one we defocused the lens a bit more. Then we combined them into one frame using processing software. It's a very artificial composition, but it does give a flavour of one of the things that makes observing and imaging Orion special.

WILL GATER X 11

▲ Combining progressively defocused images of Betelgeuse (left) and Rigel (right) will highlight the contrasting colours of Orion's brightest stars

Portrait of a stellar nursery

Capture the Orion Nebula's ethereal pink swirls of gas and dust that are giving birth to new stars

EXPERIENCE LEVEL Intermediate to advanced

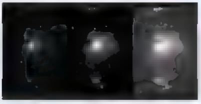
WHAT YOU'LL NEED A small refractor or Newtonian telescope carried on a motorised tracking mount, plus a monochrome CCD camera (and a computer to control it) with a set of LRGB imaging filters and a filter wheel. For exposures of more than a few minutes it's also a good idea to use an autoguiding system alongside the above, though this is not absolutely necessary.

There are few greater tests of a deep-sky astrophotographer's skills than the magnificent Orion Nebula, M42. Among the many challenges it provides are the faint outer regions of the nebula that can be lost in processing, or simply not picked up at all during the imaging process, and its dazzlingly bright core that requires careful planning to capture. In the step-by-step guide below we've described the basic process of how to go about shooting M42 with the kind of setup you might typically have if you're starting out in CCD imaging – that is, a monochrome CCD camera and a set of LRGB filters (luminance, red, green and blue) with which to make a full-colour image


Capturing all the detail and colour of the Orion Nebula is a challenge

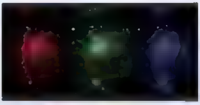
STEP 1 Set up and polar align accurately

Once you've got your equipment set up, spend some time finessing the polar alignment of your mount. This is so you'll be able to get the longest unguided exposures your mount is capable of before the stars drift out of position – this is especially important if you're not using autoguiding equipment



STEP 2 Capture different length luminance exposures

Use short, 'binned', test exposures to compose the image. Then take three groups of exposures through a clear luminance filter: short ones for M42's bright core, longer ones for the main body and, for the faint outer regions, as long as your unguided mount can manage without the stars 'wandering' (usually several minutes)



STEP 3 Get the RGB colour

When you've got 10–15 sub-exposures for each of the three groups of luminance data, you can move on to capturing the colour data through red, green and blue filters. Capture at least 10–15 images per colour channel – aim for an exposure length similar to your shots of the main body of M42 with the luminance filter

STEP 4 Take dark frames and flat fields

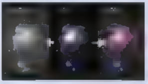
After capturing each 'LRGB channel, carefully stretch a clean white pillowcase or t-shirt over the scope aperture (without touching the lens) and illuminate it with a torch before taking an image. This is a flat field, which records image artefacts such as vignetting and dust on the optics. Also take a set of dark frames if the data from your CCD needs them

STEP 5 Stack and calibrate the data

You should now have six sets of sub-exposures: three luminance groups of varying exposure lengths and one for each of the RGB channels. Load them into your preferred astronomical image-processing software (for example, DeepSkyStacker) and use the flat fields and dark frames to calibrate them before stacking those calibrated sets into six images

STEP 6 Combine the three luminance images

Bring the three luminance images into layers-based image processing software, such as Photoshop or GIMP. With each image in a separate layer, erase the overexposed portion of the long-exposure image so that the 'main-body' exposure shows through – do the same for the main body layer so the core shows clearly. Merge the layers



STEP 7 Add the colour and make final processing adjustments

Next, place your red, green and blue filtered images in their respective colour 'channel' in a new image file. Copy the resulting full-colour image, as a separate layer, into the luminance file created in Step 6 and turn its blending mode to 'Colour'. Lastly, make any final image tweaks to your taste

For those of us unable to see the aurorae, there's another way to experience the effects of particles streaming from the Sun on Earth's atmosphere

Measuring the aurora

Creating a homemade magnetometer allowed **Stuart Green** to keep a record of space weather, despite cloud and his southerly location

ABOUT THE WRITER
A composite materials engineer, Dr Stuart Green is a keen solar astronomer and space weather enthusiast

Earth is bathed in a constant stream of energetic particles originating at the Sun. This solar wind ebbs and flows, and occasionally explodes in a coronal mass ejection, throwing billions of [illegible] of our star's plasma into space, which impacts on Earth's magnetosphere – our protective magnetic bubble. The result is bright and beautiful aurorae, the luminous splendour of which is our only visual confirmation of the Earth–Sun connection. For those fortunate enough to witness this spectacle, the lasting impression is one of awe at its magnificence. For the rest of us, such events are lost save for the images [illegible] can only experience the aurorae vicariously.

A few years [illegible] establish a degree of connectivity with the Sun that was otherwise unavailable to me in my lower latitude location in the UK. That's when I thought about building a magnetometer. Not only does the solar wind create the aurora, but in the process of [illegible] our protective bubble. This is detectable at any [illegible] picks up the magnetic signature as it fluctuates according to the strength, speed and magnetic orientation of the passing plasma.

Magnetometers can be purchased commercially, of course, but my interest lay in building one for the [illegible] of it and for the challenge. The basic scheme of the design is a highly sensitive magnetic sensor, an ultrasonic emitter, an ultrasonic-to-audio frequency converter and a computer with a sound card and Spectrum Lab audio [illegible] software for data logging.

A stable environment

[illegible] these sensors can be extremely sensitive and are perfectly suited to measuring the tiny perturbations in the local magnetic field caused by space weather. The particular sensor I used provides an output frequency that varies according to the strength of the magnetic field.

As well as responding to the magnetic field, the [illegible] stable environment. My sensor is buried in my [illegible] 40mm diameter plumbing pipe fitted with end caps sealed using suitable solvent.

The sensor is positioned almost perfectly level on a poured concrete base and points along [illegible]

• DC from a mains transformer to a stable 5V DC supply

When pointing east west, the output from the fluxgate sensor is a train of +5V square wave pulses at a frequency in the range of 60–70kHz, which is significantly above the operating frequency of any standard computer sound card. So I turned to equipment intended for zoology and connected the output of the magnetic sensor to a bat detector with an ultrasonic transducer emitter.

Bat detectors are designed to convert ultrasonic bat calls into audio frequencies that we can hear. Commonly this is accomplished by a process called heterodyning, in which an internally generated, tuneable reference frequency is mixed with the varying ultrasonic input signal from the bat to create audible sound at a frequency equal to the difference between input and reference frequencies.

Frequency range

For the purposes of magnetometry, this frequency difference should be tuned to a single audible tone that can be recorded with a standard computer sound card. I found 3–4kHz to be a suitable range. The other advantage of using a bat detector is that the audio output is of good fidelity, meaning that subsequent data analysis can be accomplished at high resolution. For this project I used a detector with an internal crystal oscillator for precision and to minimise any frequency drift. This detector is

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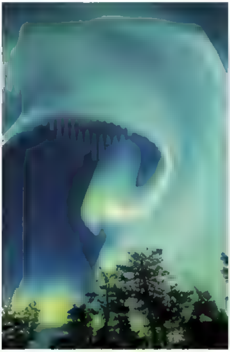


The sound of space weather

Once the data from the solar wind hitting Earth's magnetosphere has been collected, it's possible to create an audio file from it

Taking things a step further with an online algorithm, it's possible to convert the output magnetic field strength data into sounds using the MIDI (Musical Instrument Digital Interface) protocol. In this process, each field strength value is converted to a MIDI value representing a particular musical note, which is then fed into music production software to prepare an audio track.

MIDI allows any digitised instrument to be assigned to play the note, although my preference is to use a synthesised wind sound to represent the solar wind. In reality, the data relate directly to local magnetism, not to the solar wind, yet to hear the sounds generated by such a method is evocative as one imagines the stream of particles pushing against our protective magnetic field, occasionally entering to create the ethereal aurora.

Once the magnetic declination data generated by my magnetometer was sonified, it could be synchronised with a timelapse video of the aurora borealis to create an audio-visual experience similar to this one: bit.ly/2n9ohFo. The correlation between the video, created by Kai-Marius Pedersen in Tromsø, Norway, and the audio is not perfect – probably because of the physical separation between it and the sound recording in the UK – but there is a satisfying degree nevertheless. More sonified geomagnetic data can be found at bit.ly/2n9rHc1

"I now have a connection with the cosmos, with data streaming into my PC constantly, capturing the ebb and flow of the solar wind"

usually powered by a set of batteries, but as that only provided a battery life of less than 24hours, the batteries were swapped for another stabilised DC feed from the 9V mains transformer.

Gathering data

With the detector set up I was ready to log data, and for this I used free software called Spectrum Lab, written by Wolfgang Buescher (www.qsl.net/dl4yhf/spectra1.html). This enables the data stream to be displayed as a continuous chart as the day progresses. The software can also send measured frequency data to a computer hard drive at preselected intervals, together with a time and date stamp, building up a database throughout an entire geomagnetic event. Later, this database can be exported as a CSV file and copied into an Excel spreadsheet for further analysis. Any time period between logged events can be selected; I use a one-second cadence for high resolution work and a 150-second cadence for standard resolution work.

Analysing the data involves converting frequency to magnetic field strength (more accurately magnetic flux density in nano-Tesla) using conversion factors provided by the sensor manufacturer, and then charting the result as a function of time.

As it turned out, my magnetometer needed a few refinements to make it more consistent with professional data, in particular better temperature control of the bat detector. The output from the detector was being significantly impacted by small ambient temperature fluctuations that were imprinting on the output frequency. It was only when the detector was placed in a temperature-defined environment (inside a vacuum flask inside a cool box fitted with a vivarium heater mat at a controlled temperature) that the output met the professional readings.

The output from such a relatively simple device is remarkably consistent with data generated by professional geomagnetic monitoring stations such as Eskdalemuir, operated by the British Geological Survey, and its sensitivity and resolution certainly compete favourably for the hobbyist with the output from magnetometers costing considerably more.

Having established my homemade magnetometer I now have that connection with the cosmos that I was looking for, with data streaming into my PC constantly, capturing the ebb and flow of the solar wind and occasional coronal mass ejection that buffets our planet.

Get a steer from our astro experts on the equipment that they've found essential

Take it from me

TIPS FROM THE ASTRONOMY EXPERTS

Experienced astronomers reveal to Will Gater the secrets they've learnt from their hundreds of hours of stargazing and astrophotography

When you're looking to brush up your stargazing skills, whether it's observing, imaging or processing techniques, or deciding which equipment is worth buying, one of the best ways is to pick the brains of knowledgeable friends who can offer you advice, or even show you how something's done. That's why we've spoken to four experts to find out the most useful things they've learnt over the years, what mistakes to avoid and the most important things they think every beginner should know. Over the next few pages you can find the distillation of those conversations and we hope it'll be just the thing to guide you through those crucial early steps.

Sara WAGER

DEEP-SKY ASTROPHOTOGRAPHER

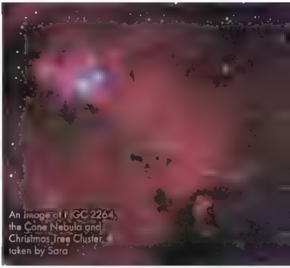
Sara started out in astrophotography in 2010. With the help of astronomy forums and books, she learnt imaging techniques and is now one of Europe's leading deep-sky astrophotographers. From her observatory in Spain she regularly produces stunning pictures of galaxies, nebulae and star clusters

"I would say the biggest challenge in deep-sky imaging is getting used to the mount, so that you're able to polar align. Without polar alignment you're not going to get longer exposures – certainly if you're not autoguiding.

"People seem to think there's a rite of passage in which you go from a DSLR to a one-shot colour CCD camera and then to a monochrome CCD. I don't necessarily think people should feel that they have to progress like that. If you've got the inclination, and you think it's going to be a hobby that you'll enjoy, then buy secondhand equipment and just jump in at the deep end.

"Your neighbour's probably not going to be doing astrophotography as well so they can't stand there and help you, but that doesn't mean you're on your own. Internet forums are fantastic – I've gained so much information from them and made so many friends. It's unbelievable.

"I've learnt that refractors are far easier to use and, for me, are the better option. I started off with refractors before moving on to a Schmidt-Cassegrain telescope, a Ritchey-Chrétien and then an optimised Dall-Kirkham. But I've gone back to a refractor because it's just easier. I don't want to waste time faffing around; I just want to switch everything on and go.



An image of NGC 2264, the Cone Nebula and Christmas Tree Cluster, taken by Sara

"As you get more experienced, the way you compose a shot changes. You learn to balance things out, look around and see what else is there. I think that's really quite important, because that ultimately gives you more interesting pictures.

"When it comes to executing that composition, I've found plate solving software is incredible. It'll take a picture of the sky, compare it to various catalogues that it's got on record and then tell you exactly where you are. For example, say you want to photograph the Pinwheel Galaxy, M101 and have framed it in the top left-hand corner. You can tell the software this is where you want it to go and it'll take a picture, then say, 'Actually you're 6,000 pixels away', and move the frame by 6,000 pixels. It'll take another picture, then say 'You're still three pixels out' and make the three-pixel adjustment. After a few shots you'll be in exactly the right place night after night, and can even go back to it year after year. With an image from last year, I can plate solve it then ask the software to point the scope at the same spot and that's where it goes." ▸

Richard FLEET

VISUAL OBSERVER

It was the Moon landings that steered Richard towards astronomy. One of his early optical instruments was a pair of Second World War binoculars, which he recalls using to observe the Andromeda Galaxy. Today he's an experienced visual observer, astrophotographer and an expert in meteor astronomy

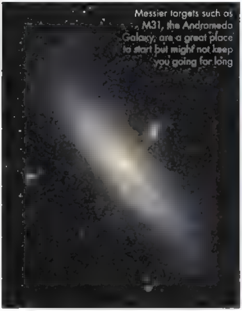
Binoculars are a great way to get a taste of astronomy before spending big money on a scope

"Beginners often ask me what telescope to buy and I reply 'Don't buy a telescope. Just get a pair of binoculars and learn how to use them.' If what you see through the binoculars is impressive, then consider investing in a telescope. Astronomy is impressive, but it's not necessarily a visual spectacle – it's understanding what you're looking at that's the key. Binoculars are enough to do that.

"If you do decide that you want a telescope don't buy one until you've tried viewing through the telescope you intend to buy and have experienced the sort of views you're going to see with it. Judging purely on the pictures of the views a telescope can offer often leaves people disappointed by what they actually end up seeing.

"With telescopic observing I think you need to be interested in something. If you're just looking at Messier objects you'll run out of targets quite quickly. I got interested in variable star observing because a member of my local astronomical society encouraged me to view things over a long term. With variable stars you don't see what's going on during a single night. You have to build up a series of observations to understand what's happening. So I think you've got to do a bit more than simply spotting objects, otherwise you're not really getting the benefit. It's nice to get the Messier objects, but what do you do once you've seen them all? This is where things like variable stars and comets come in.

"One of my big regrets is that I don't write things down enough. I don't keep a diary and I think, looking back, there are a lot of things I've forgotten. The background around an observation is often just as interesting – not so much what I saw, but the adventure of observing it. Those are just memories for me now and eventually I'll lose them."



Messier targets such as M31, the Andromeda Galaxy, are a great place to start but might not keep you going for long

Top 3

RICHARD FLEET TOMMY NAWRATIL/CCDGUIDE.COM LYN SMITH X 2

Lyn SMITH

SOLAR OBSERVER

PROTECT YOUR EYES
Solar observing can be dangerous. Never view or photograph the Sun without using a certified solar filter that has been sourced from a reputable supplier and which is used and installed as per the manufacturer's safety instructions. Also, be sure to remove or cap any finderscopes your telescope may have prior to observing.

Lyn has been fascinated by astronomy since she was seven, but it was a programme on solar observing presented by Sir Patrick Moore that sparked her specific interest in our nearest star. Today she's the director of the British Astronomical Association's Solar Section

Top 3

Lyn's favourite solar phenomena to observe

[illegible]
"Cooler regions of the Sun's 'surface' that appear as dark blemishes on the bright solar disc."

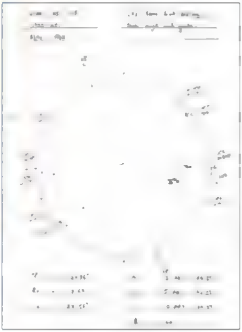
[illegible]
"A vast cloud of plasma leaping off the Sun – these are only visible using specialist hydrogen-alpha solar telescopes and filter systems."

[illegible]
"A powerful explosion on the Sun that appears as a very bright patch (typically near an active region or large sunspot). You can view these through specialist hydrogen-alpha-filtered solar telescopes."

"When you start observing it can feel like there's a lot of pressure on you to become an expert on everything straight away, and trying to do that isn't what you want to do at first. You need to enjoy it. You need to start simple, learn a little bit and then progress onto the next stage.

"Never look through a telescope at the Sun unless you've got a solar filter on it. You can look through a telescope as long as you have a good-quality solar filter that uses Baader AstroSolar Safety Film – that gives you a nice, white, silvery image. Alternatively you can buy a Type 2 glass solar filter and put that over the objective end, which will give you a kind of yellowy-orange Sun.

"The good news about solar astronomy is that small is beautiful. Normally in astronomy you're trying to capture as much light as possible, so you need a big aperture. With solar astronomy it's the opposite: you've got too much light so a nice small-aperture telescope is what you're after.



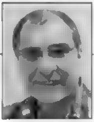
▶ Sket[illegible] sunspots a[illegible] you both a greater insight [illegible] and [illegible]

Lyn using her 3.5-inch Meade refractor for solar projection

"I sketch every single observation, which I think really helps. If you're trying to count sunspots or anything, you need to draw it. It helps your brain sort out what's there and helps you count. It's all too easy to just look at the full picture, but when you're drawing something you have to concentrate more on the detail.

"Bring the sunspot, filament or whatever you're looking at into the centre of the eyepiece. Then you'll see it far better. Wait for that moment of clarity of fine seeing. There's that fraction of a second where it's so clear you see everything and then it's gone again. That's why observations take a while: you need to keep waiting for that moment of perfection and then quickly sketch it down.

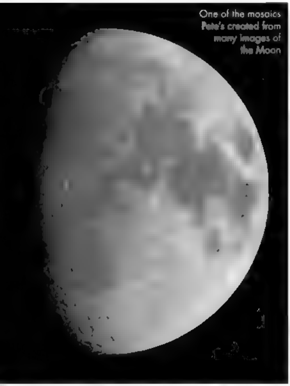
"The most difficult thing for me to comprehend as a beginner was the orientation of the solar disc. It can be so simple to work out east from west when you know how, but I wish I'd had someone to tell me when I first started. Just let the solar image drift through the eyepiece and the first limb to slide out of view is the western limb. That's a really good thing to get in your head." ▸



Pete LAWRENCE

HIGH-RESOLUTION LUNAR AND PLANETARY IMAGER

Today, Pete is an experienced imager of the Moon and planets, but his first shot was taken by pointing a digital camera down the eyepiece of a telescope. He now uses high-frame-rate cameras and a large-aperture Schmidt-Cassegrain telescope to capture spectacular pictures of our celestial neighbour



One of the mosaics Pete's created from many images of the Moon

"A big danger in astronomy, as in many walks of life, is that once one method of imaging the Moon and planets becomes second nature, you tend to assume that it's the only method there is and that you shouldn't vary from it. That's wrong. You shouldn't assume that the way you're doing something is the only correct way – you should always experiment and try different things. And don't be afraid of making mistakes.

"I made plenty of mistakes when I started out. My first images of Mars looked like somebody had taken a photograph of a baked bean, because it showed very little detail – it was just an orange blob. It needed that push to increase the image scale in order to bring out some of the surface details. Image scale is basically how big something looks on your imaging chip. The longer the focal length of the telescope, the larger the object you're imaging will appear. You can't change the physical focal length of your telescope but you can change the effective focal length by using an optical amplifier such as a Barlow lens or a Powermate. For example, a 2x Barlow will give you a focal length that's effectively two times your telescope's natural focal length.

"But beware: there is a danger associated with doing this. If you increase the image scale too far, the planet or the Moon will just look like mush because you need perfect conditions to do that. You're not using the camera's pixels at their optimum efficiency.

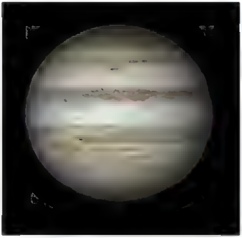
"One of the best ways of processing an image – whether it's deep-sky, planetary or lunar – is to fiddle about with it to create your final image, then walk away from it for 20 minutes or more. When you come back and sit down in front of it, your image will either look good or it'll look awful. Don't worry if it looks awful, everyone produces bad images from time to time. When you're processing, it's all too easy to tweak an image to death, but if it's not working, just walk away. When you come back you'll see the processed result for what it is."

Top 3

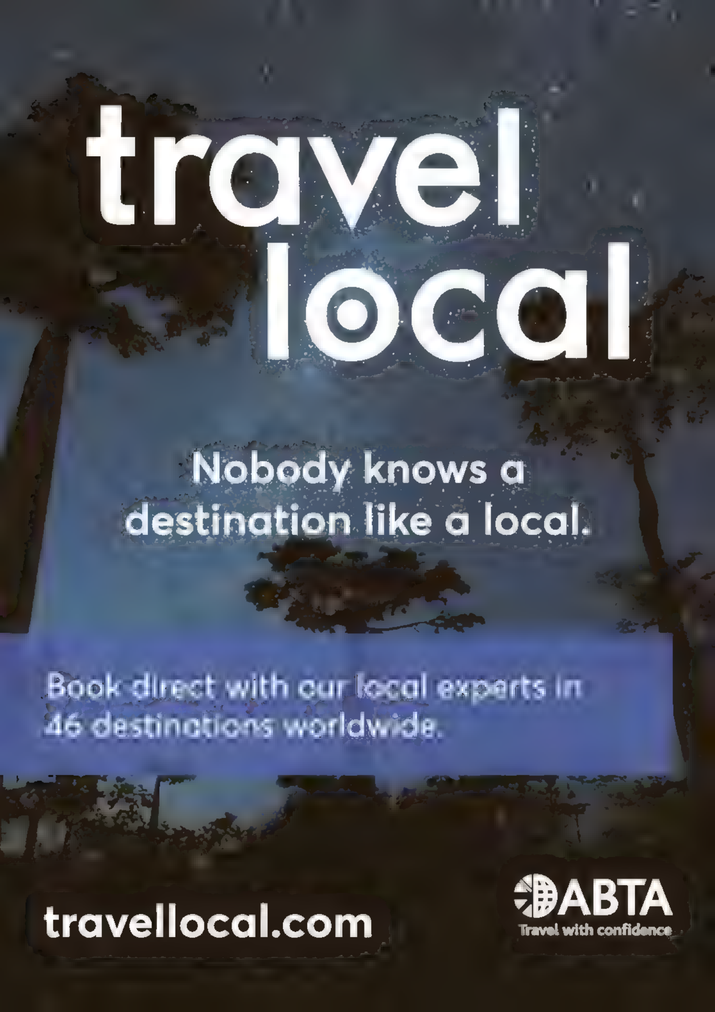
1. [illegible]

2. [illegible]

3. [illegible] focus is spot on. [illegible] through focus, out the [illegible] looks like."



PETE LAWRENCE X 2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Nobody knows a
destination like a local.
Book direct with our local experts in
46 destinations worldwide.
travellocal.com
ABTA
Travel with confidence

STELLARIUM

Stellarium, created by French programmer Fabien Chéreau in 2001, is a ubiquitous astronomy tool for the digital age

UNCOVERED

Astronomer Will Gater shows you how to master the free planetarium software Stellarium and make the most of some of its more advanced features

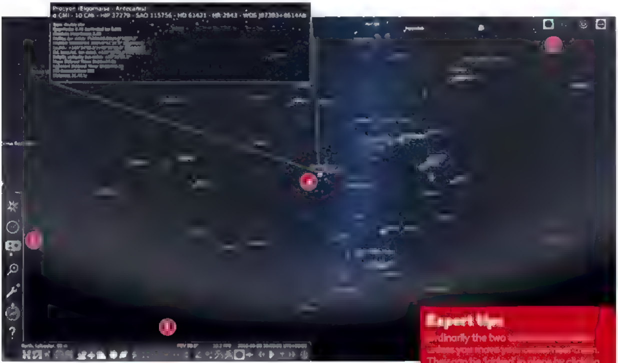
There are few pieces of software that have made such a contribution to amateur astronomy as the free planetarium program Stellarium. Available from stellarium.org for Windows, Mac OS X and Linux systems, it is popular with beginners and advanced stargazers alike. Indeed, not only can it do everything you'd want from a planetarium program – that is, simulate the night sky and the positions of planets and other celestial bodies at a given date and time – but it's also packed with other features that are tremendously useful for experienced observers and astrophotographers.

Here we take a look at the basics of the program – so that if you're new to it you'll have an introduction to how to use the software – before then exploring further by examining Stellarium's plug-ins and other useful tools that even we, with decades of stargazing experience under our belt, come back to use time and time again. We suggest you fire up the program while you read this so you can experiment as we go. ▶

ISTOCK X 2, ALL SCREENSHOTS: WILL GATER/STELLARIUM

The basics of Stellarium

The symbol-based menus may seem arcane at first, but this guide will quickly get you up to speed



Expert tips

Ordinarily the two [illegible] unless you move your [illegible]. They can be locked in place by clicking the tiny triangles on the L-shaped tab in the bottom-left of the Stellarium window.

The main screen

1 There are two main toolbars. The bar along the bottom shows key information such as the location, the field of view (FOV) and the time. Placing your cursor over this bar will raise it to reveal buttons that can toggle display settings, such as constellation lines and star labels. This bar is also where some plug-in buttons will appear.

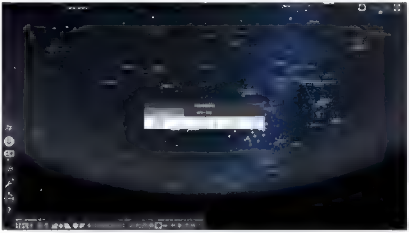
2 On the bottom-left is another toolbar to access further configuration windows, to select the location you're observing from, set the date and time, and tailor what's shown on screen. The Search tool and Help window are also here.

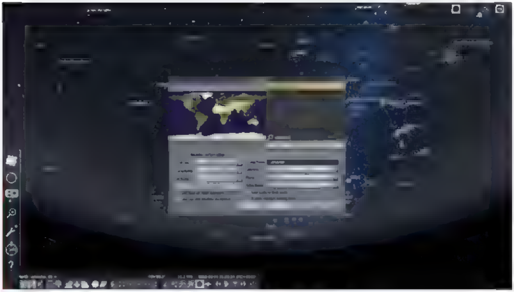
3 If you have the Oculars plug-in (see page 26) you will see its icons on the top-right.

4 If you left-click on a celestial object from the main screen, the object will acquire a small rotating target around it (stars) or a bouncing blue frame (other objects). Information about the object will appear at the top of the screen, including its name, magnitude and catalogue numbers. Press F2 to customise this display in the 'Information' tab.

Setting the date and time

When Stellarium first opens, it synchronises with your computer's date and time. If you open it during the day it'll show a simulated daytime sky; to see the stars come out you'll need to advance the time. But the program handily lets you specify a time (say 11pm) that Stellarium will default to every time you open it: press F2 to access this on the 'Navigation' tab. In general use, if you want to display the sky for a specific date and time, simply click the clock on the left toolbar and input the desired values.





Setting the 'viewing' location

Selecting the location from which you want to view the sky in Stellarium is simple. Click on the compass icon in the left-hand toolbar or by pressing F6 to bring up the 'Location' window. In that window, you can then choose a location either by clicking on a world map then selecting from a list of nearby places or by typing in a town or city, or inputting an exact longitude and latitude. You can even select an extra-terrestrial viewing location if you want to simulate the sky from other bodies within the Solar System.

Expert tips

Stellarium allows you to customise the size of stars relative to each other on-screen (press F4, Sky tab). We [illegible] set the 'Absolute scale' to 2.2[illegible] and the 'Relative scale' to 0.5[illegible] as that gives a more photorealistic look that's useful for astrophotography planning.

Exploring Stellarium's sky

To explore the sky in Stellarium you can drag it round with your mouse or use the arrow keys on a keyboard. To zoom in and out use 'ctrl' (or 'cmd' on a Mac) plus the up and down arrows, or you can use a roller wheel on a mouse. To zoom in on a specific target first left-click on it, then press the spacebar to centre it before using the zoom keys.

How to tweak what Stellarium shows

Pressing F4 brings up a 'Sky and viewing options' window. Here you can change the size of the stars, adjust the number of labels and limit star magnitudes (useful for decluttering the chart) and simulate light pollution. From the 'DSO' tab you can choose which catalogues of deep-sky objects are flagged, while the 'Markings' tab allows you to switch between various celestial markers, lines and coordinate grids. The 'Landscape' and 'Starlore' tabs let you change the foreground scenery and alter which culture's star names and constellation patterns are used. ▸

Using the search function

Stellarium's search menu can be accessed by pressing F3. Pressing the 'return' key on a successful search will immediately centre that object on the screen.

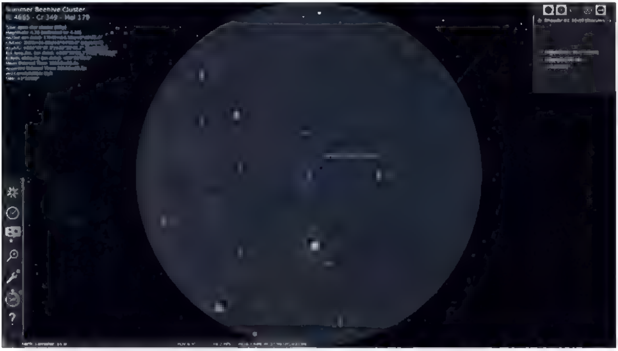
Other stargazing software choices

There are many other sky charts programs available if Stellarium doesn't quite fit your virtual stargazing requirements.

Sky Safari: skysafariastronomy.com
Starry Night: www.starrynighteducation.com/index.html
Cartes du Ciel Skychart: www.ap-i.net/skychart/en/start
Google Sky: www.google.com/sky
Redshift: www.redshift-live.com/ext/en
ESA Sky: sky.esa.int
Sky Map: www.sky-map.org

Advanced features

Here we delve deeper into Stellarium to look at some of the useful plug-ins for imagers and observers



Simulating eyepiece and camera fields of view

Stellarium comes with an extremely useful feature – the 'Oculars' plug-in – that allows you to simulate the field of view of a given eyepiece and telescope combination, as well as overlay the field of view of a camera and optics setup onto the sky. Of all the plug-ins in the program this is the one we use the most, and its ease of use makes it a superb tool for planning astrophotos. The plug-in can be activated by accessing the 'Configuration' window using the F2 button, then clicking on the 'Plug-ins' tab. Scroll down the menu on the left to 'Oculars' then click on the 'Load at startup' button. When you reopen Stellarium you'll see a new toolbar has appeared in the top-right of the screen.

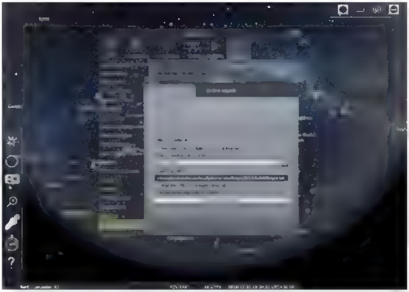
The rightmost of these (a spanner symbol) brings up Ocular's configuration window where you can list what telescopes, eyepieces and cameras you own. The second button activates a camera field of view tool that places a red box onto the simulated sky, representing the boundary of the view of the specified equipment. The third icon switches on a circular 'target' pattern that's used in Telrad finders. Swapping between various equipment combinations in the program is easy: click the double arrows next to each piece of equipment listed in the box under the toolbar, which appears when either the eyepiece field of view or camera field of view tools are in use. The camera field of view can even be rotated by increments so you can experiment with the idea framing of a potential astro image.

Expert tips

Clicking on the 'eye [illegible] tints [illegible] using the program while observing.

ALL SCREENSHOTS: WILL GATER/STELLARIUM

Using and updating the 'Solar System Editor'



Stellarium doesn't just simulate the positions of stars, deep-sky objects, the planets and the Moon. It also shows where numerous asteroids and comets are located at any given moment. New comets and asteroids are discovered frequently and you can keep the program's databases up to date using the 'Solar System Editor'. Press F2 to find it in the plug-ins menu.

Clicking the 'Configure' button on the Solar System Editor page brings up a new window with a 'Solar System' tab. The button to 'Import orbital elements in MPC format' lets you import orbit data for asteroids and comets from lists maintained by the Minor Planet Center; simply select a list and click 'Get orbital elements'. Choose which bodies you want Stellarium to plot before clicking 'Add objects'. You can then search for these objects using Search (F3).

Expert tips

To find whether a m… see which radiant its path matches.

Showing satellites

Among Stellarium's many excellent advanced features, the 'Satellites' plug-in is likely to be the one of most interest to watchers of humanity's orbital outposts. Once enabled via the 'Plug-ins' menu, it plots the positions and movements of a huge number of satellites. This is not just interesting to look at, it also creates a superb planning tool for photographers who enjoy taking pictures of things like the International Space Station, geostationary satellites and iridium flares – especially when used with the camera field of view function of the 'Oculars' plug-in. For example, if the ISS is going to make a pass over the location that Stellarium is simulating, the program will show it as a bright point of light moving against the stars, just as you would see it in real life. Stellarium can even simulate the Station going into – or emerging out of – Earth's shadow and the behaviour of iridium flares with the satellite momentarily brightening dramatically before fading. To make the path of the ISS even clearer we advise checking the 'Orbit Lines' box on the plug-in's configuration page.

BBC Sky at Night MAGAZINE

Equipment reviews

BEST OF 2018

Over the past year we've tested 36 items of astronomical equipment. Here are five of the finest to have passed through our labs

Celestron Astro Fi 5 Schmidt-Cassegrain

Let your smartphone be your guide with this easy-to-use mount for beginners

Optics

The Astro Fi 5 is a Schmidt-Cassegrain telescope comprising a primary mirror and a corrector plate with the secondary mirror attached to the corrector. It has a 'long' focal length of 1,250mm giving a focal ratio of f/10, although strictly speaking it works out at f/9.8. All optical surfaces are multicoated

Single arm mount

The single arm mount holds the electronics and gears and is very solid in build quality. The mount has a Vixen-style saddle for attaching the telescope, with a good, chunky retaining bolt giving a solid grip to the Vixen bar on the telescope

Tripod

The tripod has aluminium telescopic legs that can be extended and was sturdy to use. The mount affixes very easily with a single underside bolt from the tripod which holds it firmly in place. The spreader tray can hold two 1.25-inch eyepieces and there is a rubberised smartphone holder

Accessories

The StarPointer red dot finder worked well for aiming the telescope, especially during alignment. Two eyepieces are provided, 25mm and 10mm, which give magnifications of x50 and x125, along with a 90° star diagonal. The eyepieces gave good views of all our targets but especially of the planets and the Moon

Ports

The mount incorporates several ports including two aux ports, one of which can be used for an optional hand controller, the other is a spare port for future use. There is also an integrated Wi-Fi adaptor, a 12V DC power connector and on/off switch with an illuminated 'on' light

Celestron's Wi-Fi controlled Astro Fi 5 comprises a 5-inch (127mm) Schmidt-Cassegrain telescope on a single fork arm attached to an aluminium tripod. The telescope has a focal length of 1,250mm giving a focal ratio of f/10 which means this is considered a 'slow' system, best suited to observing planets, lunar and bright deep-sky targets. It looks very smart in its Astro Fi livery while the optical surfaces come with Celestron XLT multi-coatings for a crisper quality view.

The single fork arm has a Vixen-style mounting saddle to which you attach the telescope using a chunky restraining bolt; it was pleasingly easy to install on the tripod. A padded power pack, which takes eight AA batteries (not included) is provided and you can also use an optional power tank. The power switch has a small red LED, which is handy. A StarPointer red dot finder, star diagonal and two eyepieces complete the system. The 25mm eyepiece gives a magnification of x50 while the 10mm eyepiece provides x125, a good range for the kind of targets you'd use this system for.

The Wi-Fi/smartphone control of the system worked well. Powering up the Astro Fi 5 and connecting via the SkyPortal app (iOS and Android), we were soon aligned using the on-screen instructions. We could then use the app to explore our targets or manually slew the scope using the onscreen arrows.

The Astro Fi 5 is a decent, easy-to-use system aimed at beginners who want to enjoy the night sky using their smart devices. It certainly managed to fulfil its criteria and can be recommended

- **Price** £599
- **Optics** 127mm SCT compound
- **Focal length** 1,250mm, f/10
- **Mount** Wi-Fi Go-To altaz single-arm mount
- **Ports** Power connector, two aux ports, integrated Wi-Fi adapter
- **Tracking rates** Sidereal, lunar, solar tracking
- **Tripod** Adjustable tripod with accessories tray including rubberised smartphone holder
- **Extras** StarPointer red dot finder, 25mm and 10mm 1.25-inch fit eyepieces and star diagonal
- **Weight** 7kg
- **Supplier** David Hinds Ltd
- **Tel** 01525 852696
- **www.celestron.uk.com**

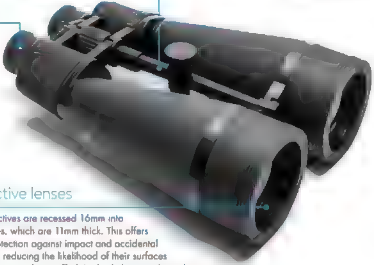
VERDICT

Objective lens caps

Poorly fitting objective caps are about as useful as a chocolate fireguard. Luckily, the plug-in objective caps on these binoculars are excellent, they provide a tight-fitting seal and can only be removed by using the tabs provided. If you lose them, it won't be because they fell off in a field somewhere

Central mounting bar

As well as conferring rigidity between the optical tubes, the central mounting bar has a sliding mounting position which enables you to easily balance the binoculars on the mount. This design also keeps the binoculars' centre of mass close to the mounting head's altitude fulcrum, this reduces balance asymmetry at different altitudes



Folding rubber eye cups

The soft rubber eye cups easily conform to the shape of your eye sockets, making them comfortable to use. They fold down to give an effective eye relief of 15mm, which we found to be adequate to allow us to wear spectacles for observing

Carry-case

The case has side rings so you can use it like a shoulder bag, but also has three rings on the back, so you can use it like a rucksack and distribute the weight evenly across your back rather than all on one shoulder

Objective lenses

The objectives are recessed 16mm into their tubes, which are 11mm thick. This offers good protection against impact and accidental touching, reducing the likelihood of their surfaces getting damaged or scuffed. It also helps to reduce glare from objects just outside the field of view

Opticron Oregon Observation 20x80 binoculars

Can these budget-priced big binos compete with more expensive models?

Big binoculars can be great astronomical instruments, but they are often prohibitively expensive. So our interest was naturally piqued when some budget-priced, 80mm aperture binoculars came onto the market.

We tested the Opticron Oregon Observation 20x80s under a variety of sky conditions, mounted on a photographic tripod with a fluid video head. Stars snapped to a good focus, which looked consistent over the central 80 per cent of the field of view. There was some off-axis chromatic aberration on the Moon's terminator and limb, but generally both colour correction and colour rendition were good. It was possible to easily distinguish the colours of Alderamin (Alpha (α) Cephei), Zeta (ζ) Cephei, Delta (δ) Cephei and Mu (μ) Cephei.

These binoculars come into their own on extended deep-sky objects. The Orion Nebula was bright, showing good structure, and we could distinguish all four stars of the Trapezium (Theta (θ) Orionis). The galaxies M81 and M82 were easy to see and the differences between them were obvious. The Andromeda Galaxy M31, nearly filled the field of view and we could detect the more abrupt cut-off owing to the dust lane on the near side. The normally difficult-to-see M33 and M101 galaxies were easily spotted when they were high in the sky, especially when we used averted vision. Although the Ring Nebula, M57, did not appear as a distinct ring, it was easy to detect and had the appearance of a disc with a darker middle.

If you fancy trying a larger-than-standard pair of binoculars without breaking the bank, the Opticron Oregon Observation 20x80s should certainly be on your shortlist, particularly if you're new to binocular astronomy. These binoculars are pleasant to use, provide crisp, clear views, have no glaring faults and also come with a five-year UK guarantee to provide significant peace of mind.

- **Price** £149
- **Optics** Fully multi-coated
- **Aperture** 80mm
- **Magnification** 20x
- **Prisms** BAK 4
- **Angular field of view** 3.26°
- **Focusing** Zeisscentre focus
- **Eye relief** 17mm
- **Interpupillary distance** 56–77mm
- **Weight** 2.2kg
- **Supplier** Opticron
- **Tel** 01582 726522
- **www.opticron.co.uk**

VERDICT ★★★★★

Altair Starwave 70 EDQ-R quad apo imaging refractor

A four-lensed, lightweight scope designed for easy, wide-field astro imaging

The first thing we noticed about the 70 EDQ-R is how light it is: with a Canon EOS 70D DSLR camera attached it weighed just 2.1kg. This really does make it a grab-and-go telescope for even the smallest of mounts and ideal for travel.

Build quality in general is very good, and it comes with quite a lot as standard. The tube is made from lightweight alloy and it comes with a good set of adjustable tube rings on a dovetail bar. A quality rack and pinion focuser with nice, smooth movement adds to the quality feel. The only thing that let it down was a loose lens cap that kept falling off.

The first target we imaged was the Andromeda Galaxy using a finder-guider configuration on a portable tracking mount set on a tripod. The camera was a Canon DSLR setup using the basic EOS capture on the computer. We took 20 three-minute images which captured lots of detail in the dust lanes with round stars and vibrant colours. For such a short amount of imaging time we were happy with the end result. The same process was repeated on a subsequent night with the Pleiades as our target, again revealing plenty of structural detail.

Changing to CMOS cameras was simple and with M42-threaded extension rings on the camera it was easy to focus on the screen. When you're using a mono camera there's ample space to attach a small filter wheel in the imaging train if you need it. Images of the Moon with a Hypercam 183C showed a lot of detail for the aperture.

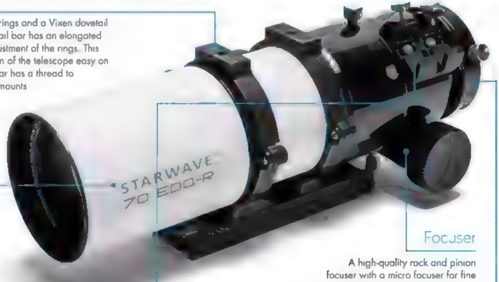
We concluded that the 70 EDQ-R is a very good addition to anyone's imaging setup. With the right camera attached it can fit some very large objects into its field of view and makes it easy to capture good images with minimal effort.

- **Price** £1,150
- **Optics** Air-spaced quadruplet
- **Aperture** 70mm
- **Focal length** 350mm, f/5
- **Focuser** CNC rack and pinion with fine focus
- **Extras** Tube rings, dovetail bar, finder bracket
- **Weight** 1.4kg
- **Supplier** Altair Astro
- **Tel** 01263 731505
- **www.altairastro.com**

VERDICT ★★★★½

Tube rings

Lightweight aluminium tube rings and a Vixen dovetail bar are included. The dovetail bar has an elongated slot at one end for easy adjustment of the rings. This makes balancing the position of the telescope easy on any motorised mount. The bar has a thread to mount on a tripod and ball mounts.



Dew shield

A sturdy built in, fully retractable dew shield helps keep dew down to a minimum in average temperatures. It is coated black on the inside to stop any stray light entering the telescope. The dew shield has adjustment screws to make a firm fit to the tube.

Focuser

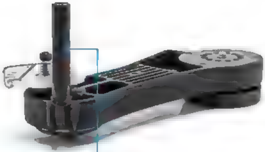
A high-quality rack and pinion focuser with a micro focuser for fine adjustment makes focusing easy. It can be fully rotated allowing the telescope to be mounted on a range of equipment without the focus knobs getting in the way. The focuser can support even the heaviest of cameras with nice smooth adjustment.

Finder shoe

Having a finder shoe is a nice touch as they're often not included on smaller refractors. Based around a Sky-Watcher finderscope, the shoe is quite generous in size and doesn't interfere with the rotation of the camera. It can also be used to mount a small guidescope or camera.

M42 rear adaptor

The M42-threaded rear adaptor is fully rotatable and makes framing targets really easy. All locking pins are nylon coated for secure locking. On the inside of the flange are adjusters to allow for sensor tilt. With the tilt adjuster set to zero the back focus is 66.78mm.



Polar finder

Equatorial mounts require polar alignment to avoid star trails and field rotation during long exposures. The MiniTrack is supplied with a very simple polar finder – an 8mm sighting tube that fits into a clip on the end of the drive unit, which works well enough

Ball-and-socket head

There is no declination axis on this type of mount so the camera and lens have to be attached to a ball-and-socket head so that they can point to anywhere in the sky. The beautifully engineered Omegon ball-and-socket head makes pointing at celestial objects very straightforward

Miniature saddle clamp

The ball-and-socket head has a well-designed saddle clamp with a single, very positive-feeling hand bolt. This saddle clamps a mini-dovetail bar forming an excellent quick-release mechanism for easy attachment and removal

Counterbalance spring

A seven-level spring tensioner is built into the mounting head to help alleviate any off-balance pressure being applied to the clockwork drive mechanism

¼-inch tripod mount

The rear of the mount has a standard ¼–20, UNC-threaded mounting hole right in the centre of the casting. This allows the MiniTrack to be attached to a wide range of tripod heads and equatorial wedges

Omegon MiniTrack LX2 tracking mount

The power to track stars is in your own hands... literally, with this clockwork device

Historically, the drives and gears used to motorise telescope mounts have been known as 'clock drives' because the original mechanisms had much in common with early clocks. The Omegon MiniTrack LX2 brings this older technology bang up to date by using a clockwork motor to power a compact equatorial tracking mount. This elegant solution makes for an ultra-portable mount with no power requirements other than a gentle winding every hour or so.

Assembly is very quick indeed. You start by attaching the MiniTrack to your own tripod's pan-and-tilt head or precision altaz head so that you can tilt the tracker to polar align it. You then attach the ball-and-socket head to the mounting platform. Finally, you attach the camera and lens to the quick release dovetail bar, which we easily managed even in the dark.

To start the imaging session, you turn the large disc at the foot of the mount a maximum of one rotation to wind up the clockwork motor – it's as simple as that. Once the motor's running, you can loosen the ball-and-socket head to allow the camera lens to point to the celestial object you want to photograph and, after focussing, image capturing can begin.

We used an external intervalometer attached to our Canon 450D and 28mm wide-angle lens set to capture a continuous set of three-minute exposures with the camera in 'bulb' mode. We used our own hot shoe-mounted red dot finder to aim the lens in the general direction of the bright star Sadr (Gamma (γ) Cygni) in Cygnus, and captured images until the motor ran out, which was exactly an hour later. The resulting star shapes were impressive, showing no sign of trailing even though we were using the maximum exposure length recommended for our kit.

We would recommend the MiniTrack to users of any experience level. More than just a gimmick, this clockwork marvel is a simple and effective means of mounting basic equipment for wide-field imaging

VITAL STATISTICS

- **Price** £139
- **Payload capacity** 2kg
- **Latitude adjustment** Adjustable wedge or pan-and-tilt tripod head required
- **Tracking rates** Sidereal
- **Power requirements** Clockwork, wound by hand
- **Tripod** Not supplied
- **Extras** Ball-and-socket head, polar finder tube, ¼–20 thread adaptor, spanner
- **Weight** 774g with ballhead
- **Supplier** Astroshop.de
- **Tel** 00 49 8191 940491
- **www.astroshop.eu**

VERDICT

Sky-Watcher StarGate 500P SynScan Dobsonian

Bigger appears to be better when it comes to telescopes

Truss and secondary assembly

The easy-to-assemble truss struts attach to the primary mirror assembly first, and then the secondary cage is attached. The latter houses the Crayford-style, dual-speed focuser and the 9x50 finderscope. The light baffle stops stray light entering the focuser assembly, while a fabric shroud (also included) can be used to protect and darken the tube

The parabolic primary mirror has a diameter of 508mm (20 inches), which provides 61 per cent more light-gathering power than a 400mm (16-inch) mirror. It has a focal length of 2,000mm, making it f/4 – a 'fast' system that gives bright views of the deep sky. There's a little coma around the edges of the field, which is typical of 'fast' systems

SynScan AZ hand controller

Sky-Watcher's SynScan AZ hand controller provides full control and setup for the Go-To and tracking with a database covering all the major catalogues, with 42,900+ objects. It can be flash updated if required and the red-backlit, soft buttons are easy to use and see

Primary mirror assembly

This houses the 20-inch main mirror, the attachment blocks for the trusses and, at the rear, the counterweights and collimation system. The latter we found a breeze to use. Once the finderscope and fabric shroud were added, an extra weight was required to achieve balance.

Mount base

The base is motorised and houses the motors and gears for both azimuth and altitude adjustments. The clutches can be slightly loosened to allow for manual movement of the mount without losing Go-To alignment, a feature known as 'Freedom-Find'

The StarGate 500P is a half-metre class instrument and weighs 90kg – make no mistake, it's not for the faint hearted.

Using it to take a tour of some of the best deep-sky targets the sky has to offer we were wowed by the views. In twilight the double star Albireo was stunning in both eyepieces. Later under dark skies, the M35 star cluster in Gemini filled the view of the 28mm and we noted coloured stars scattered throughout it. We picked up the normally fainter nearby cluster NGC 2158 which was bright and a mass of stars.

Objects that appeared as a smudge of light in smaller instruments took on new life with the 500P such as M1, the Crab Nebula, which showed as a strongly mottled oval with undulating edges and clear views of the central stars.

Turning to galaxies, we couldn't help but gasp when we homed in on the Cigar Galaxy M82, with the 10mm eyepiece and it displayed lots of the dust features we normally associate with photographs. Dropping down to the 28mm eyepiece, we could just fit its neighbour M81 in the view with a clear spiral nature to it. We homed in on Uranus and were rewarded with a lovely pale green ball instead of the usual view of a small disc. We even picked out its five moons, although Miranda was still a challenge.

Overall, the StarGate 500P is an impressive system; societies and clubs that have sufficient funds and want a real deep-sky light bucket with Go-To functionality will find that this is a great instrument to invest in. Just remember to keep a step ladder with it, as looking up towards the zenith puts the eyepiece more than 2m above the ground!

- **Price** £5,499
- **Optics** 508mm (20-inch) primary mirror
- **Focal length** 2,000mm f/4
- **Mount** Dobsonian Go-To Altazimuth
- **Ports** Power connector, SynScan AZ hand controller
- **Database** 42,900+ objects
- **Tracking rates** Sidereal, lunar, solar tracking and Freedom-Find Dual-Encoder system
- **Extras** 10mm (1.25-inch), 28mm (2-inch) eyepieces, 9x50 straight-through finderscope, fabric shroud
- **Weight** 90kg
- **Supplier** Optical Vision Ltd
- **www.opticalvision.co.uk**

VERDICT

Month by month guide to 2019

What to see in the night sky throughout the year

by **Pete Lawrence**

Key to monthly star charts

Use this key to get the most out of each month's detailed star chart

The Small Magellanic Cloud and 47 Tucanae ▷

Michael Sidonio, Canberra, Australia, 23 October 2017

HOTSHOTS WINNER JANUARY 2018

January

Optimal conditions for the Quadrantids and a total lunar eclipse are among the highs

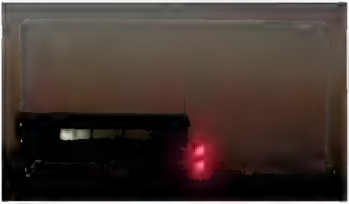
1 JANUARY
Comet 46P/Wirtanen – a naked-eye possibility

2 JANUARY
Venus, Jupiter, Mercury and a 5% waning crescent Moon visible one hour before sunrise

3-4 JANUARY
The peak of the Quadrantid meteor shower – with no Moon to mar the view

21 JANUARY
Total lunar eclipse from 02:36 UT until 07:48 UT

22 JANUARY
Venus and Jupiter appear 2.5° apart in the morning sky

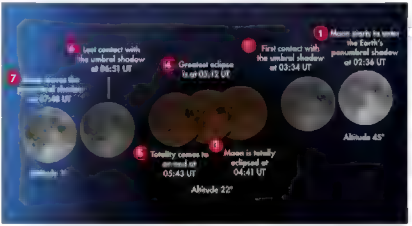


January

The New Year is heralded with a superb view of the night sky, made all the better at the start of the month by the **new Moon** occurring on 6 January. With clear weather, the bright, vibrant stars of winter will offer an irresistible invitation to explore the cosmos. The most obvious pattern is **Orion** the Hunter, seven bright stars forming a very familiar pattern. Orion is rich in deep-sky wonders, the most obvious starting point being the Hunter's Sword, a line of faint stars hanging vertically below his very obvious Belt.

The sword comprises stars and deep-sky objects. The most obvious is **M42**, the Orion Nebula. This is visible using binoculars or a telescope and appears as a swirling mass of glowing gas with a small cluster of stars at its heart called the Trapezium because of its four brightest members. A dark lane separates M42 from comma-shaped M43 to the north. Both ends of the Sword are marked by open clusters, NGC 1980 to the south and NGC 1981 to the north. Turn to page 48 to find out about more of Orion's wonders.

Another somewhat overlooked object is **M41**, an open cluster in Canis Major, the Great Dog. Starting at Orion's Belt extend the line made by the three stars down to the left as seen from the UK. They point at the brightest nighttime star of them all, Sirius (Alpha (α) Canis Majoris). M41 is located 4° below Sirius. Placing Sirius at the top of the field of view of average binoculars, M41 should be somewhere close to the bottom. The cluster contains around 100 stars and occupies an area equivalent to the apparent size of the full Moon.



Star strings and a grinning cat

Another interesting open cluster lies to the east of Orion. Starting from Bellatrix (Gamma (γ) Orionis) extend a line through Betelgeuse (Alpha (α) Orionis) for about 1.3 times the distance, bending slightly south as you go. Here you should be able to see **NGC 2244**, a small open cluster in Monoceros that bears a similarity

MOON PHASES

Key stages in the monthly cycle

6 Jan | 14 Jan | 21 Jan | 27 Jan

VISIBLE PLANETS

Where to spot the planets this month

MERCURY
Best seen at the start of the month 30 minutes before sunrise

VENUS
Reaches greatest western (morning) elongation on 6 January. Close to Jupiter on 22 and 23 January

MARS
Through a telescope, evening object Mars appears small with a distinct gibbous phase

JUPITER
Bright morning planet in Ophiuchus. Close to Venus on 22 and 23 January

SATURN
May be glimpsed in the morning sky with Venus and Jupiter at end of January

URANUS
Well placed in the evening sky best seen at the start of January

NEPTUNE
Neptune requires binoculars. Fairly well positioned, it will be best at the start of January

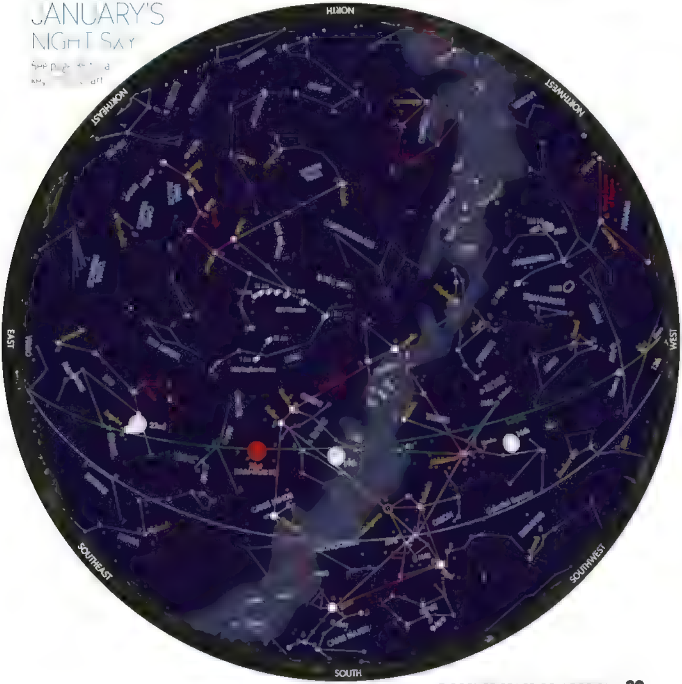
PETE LAWRENCE X 3, ISTOCK X 7, NASA X 4

to the number six on a die. Although this looks like a regular open cluster, it's special in that it marks the heart of the beautiful Rosette Nebula, a large area of circular nebulosity. The Rosette is normally the domain of long exposure astrophotography but can be seen visually through a telescope fitted with an OIII filter

As this month is turning out to be something of a cluster-fest, it's also worth mentioning **M35** at the foot of the Twin Castor in Gemini. This is a lovely object to view through a small telescope and contains many 'star-strings', patterns of stars which appear to form curving lines. Further north, following the line of the winter Milky Way through into Auriga a famous Messier trio of clusters rewards a high-altitude binocular sweep. The three are numbered out of sequence running south to north as **M37 M36** and **M38**, with M38 being part of the amusing asterism known as the Cheshire Cat

January will be an exciting astronomical month with plenty going on. Highlights include favourable circumstances for the annual **Quadrantid meteor shower peak** on the night of 3/4 January (see page 62 for radiant position), a **total eclipse of the Moon** in the early hours of 21 January and a close pairing of **Venus and Jupiter** on the morning of 22 January

JANUARY'S NIGHT SKY



◁NGC 1333

Didier Redigeruzov
David Attie Sreton
Shropshire, Exeremote
telescope hosting service
Spain, 15–30 October 2017

HOTSHOTS WINNER
FEBRUARY 2018

February

The shortest month sees the year's largest 'supermoon' and our best sight of planet Mercury

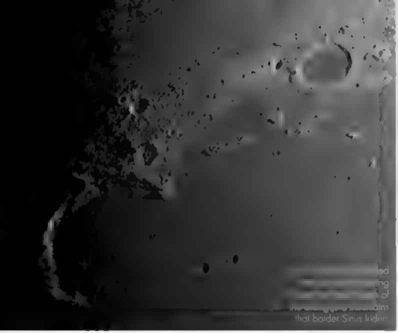
1 FEBRUARY
Jupiter, Venus, Saturn and an 11% waning crescent Moon visible in the morning sky

12 FEBRUARY
Mars and Uranus appear 1° apart

14 FEBRUARY
Jewelled Handle effect visible on the Moon

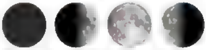
19 FEBRUARY
Closest and largest full Moon of 2019

23 FEBRUARY
Callisto sits just north of Jupiter's disc as dawn breaks



that border Sinus Iridum

MOON PHASES
Key stages in the monthly cycle



4 Feb | 12 Feb | 19 Feb | 26 Feb

VISIBLE PLANETS
Where to spot the planets this month

Evening object from mid-month that reaches greatest eastern elongation on 27 February

Morning planet near to a waning crescent Moon and Jupiter at the start of February

Evening object that appears small through a telescope

A morning planet found close to Venus and a waning crescent Moon on 1 February

A morning planet that appears near a 5% waning Moon on 2 February. Occultation reappearance visible from east and southeast England

Evening planet, best seen at the start of the month

Dim Neptune is rapidly swallowed by the evening twilight during February

February

February is an interesting month for UK astronomy. Although the nights are starting to get shorter, the rate of shortening isn't that fast, especially at the start of the month. In 2019 this conveniently coincides with a new Moon.

The bright stars of winter are still very evident but also notably drifting ever further towards the west. Following from the east are the more subtle constellations of spring, led by the very recognisable form of **Leo the Lion**. This is one of the few constellations which actually bears a good resemblance to what it's supposed to represent. The Lion's head is marked by a distinctive asterism known as the Sickle. Resembling a backwards question mark, the punctuation dot is provided by the bright star Regulus (Alpha (α) Leonis). The second star in the Sickle above Regulus is Algieba (Gamma (γ) Leonis), a close binary. Don't be fooled by mag. +4.8 40 Leonis 22.5 arcminutes south of Algieba as the actual binary is much tighter, separated by just four arcseconds.

Leo is one of 13 constellations through which the Sun passes during its annual journey against the background stars. Immediately to the west of the Sickle is another such constellation: **Cancer, the Crab**. Before we look at Cancer in more detail, keep going west and you'll arrive at **Gemini, the Twins**. This is quite an easy constellation to recognise thanks to the two bright 'twin' stars, Castor (Alpha (α) Geminorum) and Pollux (Beta (β) Geminorum). These represent the heads of Castor and Pollux, the half-twin brothers from Greek and Roman mythology, with the rest of the constellation providing a stick-figure representation of their bodies, arms and legs. Although the two stars appear very similar at first glance, look carefully and you should be able to see that they are quite different. Pollux is slightly brighter and more orange in colour.

7x50 binocular view of Mars and Uranus on the evening of 12 February

A beehive and a snake

Due south of Pollux is another bright star which looks rather isolated in the sky. This is Procyon (Alpha (α) Canis Minoris). If you join the dots by drawing an imaginary line between Procyon, Sirius (Alpha (α) Canis Majoris) to the southwest and orange Betelgeuse (Alpha (α) Orionis) in the northeast corner of Orion, this creates a large asterism known as the **Winter Triangle**.

Returning to the northern twin star Castor, draw an imaginary line from it to Regulus at the foot of the

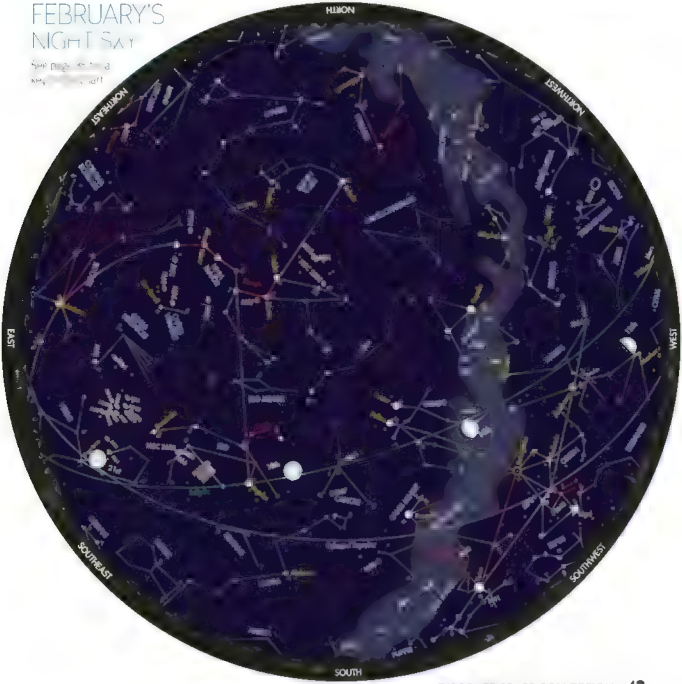
PETE LAWRENCE X 3, ISTOCK X 7, NASA X 4

Sickle. Slightly south of the mid-way point along this line is a fuzzy patch of sky just visible to the naked eye under clear conditions. This is the **Beehive Cluster** M44, which sits at the heart of Cancer. The Beehive is best seen with low-power optics such as binoculars or a telescope using a low magnification. It's interesting to compare the appearance of M44 with another open cluster in Cancer, **M67**, which lies near to Acubens (Alpha (α) Cancri). This is an ancient object estimated to be 5x further away than M44. This is most evident when you view M67 through a telescope, as it appears much smaller and dimmer.

Cancer looks like a faint inverted-Y shape in the sky. If you look south of the open end of the 'Y' you should find a distinctive sideways tear-drop pattern of stars representing the head of **Hydra the Watersnake**. This is the largest constellation by area in the entire night sky and takes a staggering nine hours to completely rise above the UK's horizon. The star Alphard (Alpha (α) Hydrae) marks the snake's neck and can be seen as the only medium bright star in a rather barren area of sky southeast of Hydra's head. Orange Alphard's name rather appropriately translates as 'the solitary one'.

FEBRUARY'S NIGHT SKY

See page [illegible] for a key [illegible] chart



The Triangulum Galaxy ▷

Alec Alden, Colchester, 17, 18, 14 and 15 November 2017

HOTSHOTS WINNER MARCH 2018

March

A chance to enjoy galaxy-laden Leo as the spring equinox arrives

1 MARCH
Venus, Saturn, Jupiter and a 23% waning lunar crescent line up in the morning sky

13 MARCH
Lunar X and V effects on the Moon visible at 16:43 UT

18 MARCH
Ganymede shadow transit from 04:00 UT

27 MARCH
Jupiter 11° from a 60% waning gibbous Moon at 01:00 UT

31 MARCH
Mars 3.2° south of the Pleiades this evening

March

MOON PHASES

Key stages in the monthly cycle

a Ma | 14 Ma | 1 Mar | 28 Mar

VISIBLE PLANETS

Where to spot the planets this month

Well placed evening planet at the start of March but lost from view from 10 March.

A brilliant morning object close to Saturn.

An evening planet passing south of the Pleiades at the end of the month

A morning planet that moves into a favourable albeit low position towards the end of the month

SATURN

Morning planet Saturn has a close encounter with a 40% waning crescent Moon on 29 March

An evening planet that is lost from view towards the end of the month

Not visible

The March equinox occurs at 21:58 UT on 20 March and indicates the point in time when the centre of the Sun's disc crosses the projection of the Earth's equator into the sky a great circle known as the celestial equator. At this equinox, the crossing marks the Sun's transition from the southern to the northern half of the sky. The equinoxes also mark the time when the length of night and day is changing at its fastest rate. The March equinox also known as the northern hemisphere's spring equinox, marks the time when the rate of shortening of the night is at its greatest. We'll have to wait six months for the September equinox, when the rate of nighttime lengthening is at its greatest. All this serves as a reminder to get a last look at magnificent Orion before he gets swallowed up by the advancing evening twilight!

Leo, the Lion is the most prominent constellation due south for much of the month. The Lion's head is depicted by the Sickle asterism with the creature's body indicated as a rectangular shape extending to the east. The medium bright star Denebola (Beta (β) Leonis) marks the end of the Lion's tail. The depiction of the cat is completed by four legs hanging below its body. The rear legs are convenient for locating a number of galaxies visible in the region

7x50 binocular view of the Moon and Jupiter shortly after rising, around 01:30 UT on 27 March

Galaxies galore

The most famous galaxies in Leo are collectively known as the **Leo Triplet**, these being M65, M66 and NGC 3628. They are visible through binoculars or with more definition through a small telescope, and are interesting because they exhibit noticeably different shapes. Located near the west-pointing front leg is another group of galaxies, known as the **M96 Group**. These are elliptical galaxies with little discernible structure, which appear as fuzzy patches when seen through a small telescope. The M96 Group includes M95, M96 and M105.

To the east of Leo is a lovely triangular smattering of faint stars that appear to shimmer in and out of visibility on a clear, dark March night. This is the open cluster **Melotte 111**, representing the beautiful sweeping locks of Queen Berenice

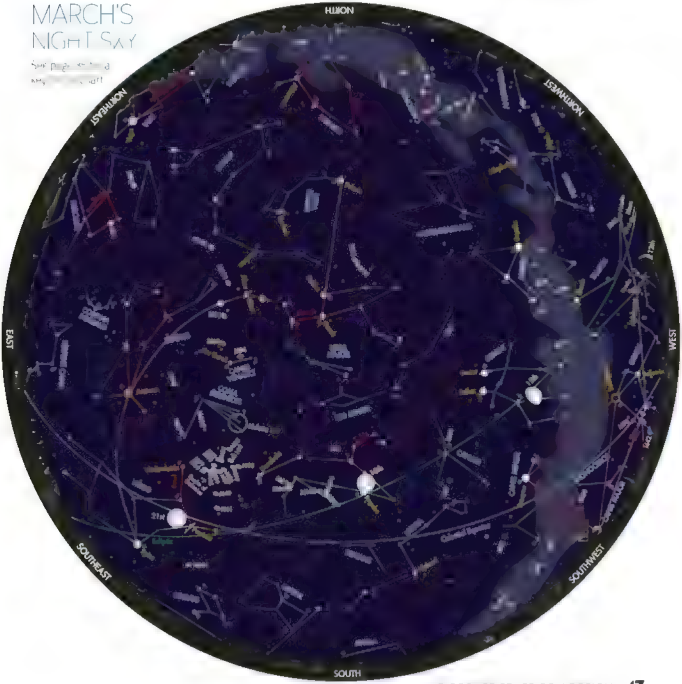
and forming part of the constellation Coma Berenices The cascade of stars appears to flow south into the open Bowl of Virgo, a name describing a large asterism of stars in the constellation of Virgo, resembling a semi-circle.

The region between Melotte 111 and the Bowl of Virgo is littered with faint galaxies, many of which can be seen with a small telescope. The region is so rich in galactic fare that it has gathered the name the '**Realm of Galaxies**'. The reason why there are so many galaxies on view here is twofold. First, the plane of our own Milky Way Galaxy which is so evident in summer and winter rotates out of the way during spring and autumn allowing us to peer out into the deepest depths of space. Secondly there are two large galaxy clusters in this direction: the Coma and Virgo galaxy clusters.

Galaxies remain important as you head north out of Coma Berenices and into **Canes Venatici**. Although a small constellation containing just two prominent stars, it plays host to M63 the Sunflower Galaxy, M64 the Blackeye Galaxy, M51 the Whirlpool Galaxy and a whole host of other, less well-known objects of similar ilk. Many of the galaxies mentioned are bright enough to be seen with nothing more than binoculars

MARCH'S NIGHT SKY

See page [illegible] a key [illegible] chart



GEMINI
TAURUS
ORION
ERIDANUS
MONOCEROS
LEPUS
Orionid radiant during shower peak 21/22 October
NGC 2169
NGC 2141
Abell 12
NGC 2022
Collinder 69
Meissa
Betelgeuse
Bellatrix
NGC 2186
NGC 2071
Collinder 70
Mintaka
M78
Alnilam
NGC 2024
Alnitak
IC 434/B33
Sharpless 2-276 (Part of Barnard's Loop)
NGC 1981
NGC 1977
NGC 1975
M43
M42
Na'ir al Saif
Rigel
Saiph
Cursa
NGC 1662

WINTER: Orion

The stars of Orion represent a mighty hunter of chequered repute, whose eventual undoing came during a hunting trip on Crete where, accompanied by Artemis, goddess of hunting, he boastfully threatened to kill every living creature on Earth. An angry Mother Earth sent a giant scorpion to teach Orion a fatal lesson Zeus placed Orion and the scorpion in the heavens as a memorial. Understandably, Scorpius and Orion can be found on opposite sides of the sky!

Orion s Belt is formed from three stars of similar brightness equally spaced in a line: Mintaka, Alnilam and Alnitak. The western star, Mintaka is positioned 17 arcminutes south of the celestial equator and effectively traces the path of this great circle throughout the course of a night. The open cluster Collinder 70 has an apparent diameter around 3° and includes the three Belt stars along with Sigma Orionis. The cluster is 800–900 ightyears distant and contains around 130 members brighter than 10th magnitude Binoculars provide the best view. Orion's 'shoulders' are marked by red supergiant stars Betelgeuse and Bellatrix

Treasures among the clouds

The main stars below Orion's Belt are Rigel to the southwest and Saiph in the southeast. Blue supergiant Rigel represents Orion's foot and is the seventh brightest star in the night sky. It's around 80 times larger than the Sun and more than 120.000 times more luminous Moving your gaze between Rigel and Betelgeuse really brings out their colour difference

The three Belt stars, Betelgeuse and Rigel are all located in a minor spiral arm of the Milky Way known as the Orion Spur This also plays host to the Orion Nebula M42, a glowing gas cloud in the centre of Orion's Sword which is represented by a line of faint stars below his Belt. A cluster of stars known as the Trapezium have formed from the nebula material and are current.y responsible for ionising the surrounding gas, causing the nebula to glow. Immediately north of M42 is comma-shaped M43, another glowing nebula

Orion plays host to the Horsehead Nebula B33. Th s is formed by a dark finger of nebulosity silhouetted against a bright curtain of glowing hydrogen known as IC 434. The silhouette resembles the prof.le of a horse's head The Horsehead is located south of Alnitak and although not easy to see visually, is a very reward ng photographic target. A brighter and visually easier nebula sits east of Alnitak the Flame Nebula NGC 2024 Another noteworthy object not too far from the Belt is the beautiful reflection nebula M78 which ies close to another reflection nebula NGC 2071

Long-exposure images reveal an immense ring of glowing red hydrogen in Orion. Known as Barnard's Loop, the ring measures 10° across. Further north, long exposures also reveal the smaller, circular nebula centred on Meissa This is known as the Angelfish Nebula Sharpless 2-264

Although Orion is brightest in winter look out for the Orionid meteor shower from 2 October unti 7 November Associated with Halley's Comet, it delivers a peak ZHR of around 20 meteors per hour, appearing to come from the region depicting the hunter's club.

ALL PICTURES PETE LAWRENCE

◁ The Jellyfish Nebula

Martin Baker, 25 November 2017 & 18 January 2018, Berkshire

HOTSHOT – WINNER APRIL 2018

April

Fingers crossed for the zodiacal light on Moonless evenings this month

START OF APRIL
The zodiacal light may be visible under dark skies

8–9 APRIL
Mars, the Pleiades and Hyades group together

14 APRIL
Jewelled Handle effect visible on the Moon

19 APRIL
Favourable lunar libration for the southeast limb

23 APRIL
Bright Moon and Jupiter close in the morning sky

April

The spring sky is in full force during April. Directly overhead is that most recognisable of asterisms, the Plough or **Saucepan**, its seven stars creating a familiar shape that, from the UK at least, never sets below the horizon. This makes it very useful for navigation. Viewing as a saucepan, locate the two stars furthest from the handle. These are Dubhe (Alpha (α) Ursae Majoris) and Merak (Beta (β) Ursae Majoris), together known as the Pointers because extending their line to the north will bring you to the Pole Star, **Polaris**.

Polaris is a medium-bright star around which all others appear to rotate as seen from the Northern Hemisphere. If you were at the North Pole, Polaris would appear directly overhead at night. Once you've found Polaris, dropping a vertical line from it to the horizon identifies due north. In addition, the altitude of Polaris above the northern horizon equals your latitude. It's a very useful star indeed.

Getting a handle on M3

Return to the Saucepan and extend the arc of its handle away from the pan to eventually reach the bright orange giant Arcturus (Alpha (α) Bootis). Keep the arc going to reach brilliant white Spica (Alpha (α) Virginis). Visualising the Saucepan's handle arc as part of a circle, at its centre is Cor Caroli in Canes Venatici. Draw a line from Arcturus to Cor Caroli and at the mid-point sits **M3**, a superb globular cluster to view through any size of telescope.

MOON PHASES

Key stages in the monthly cycle

5 Apr | 12 Apr | 19 Apr | 26 Apr

VISIBLE PLANETS

Where to spot the planets this month

MERCURY
Not visible

VENUS
Bright morning planet best seen at the start of the month.

MARS
Evening planet close to the Pleiades and Hyades at the start of April. Less visible by month end

JUPITER
Dominant but low morning planet. An 84%-lit waning gibbous Moon lies nearby on 23 Apr

SATURN
Morning object not far from much brighter Jupiter. Moon nearby on 25 April

URANUS
Not visible

NEPTUNE
Not visible

Approximate location of the zodiacal light 90 minutes after sunset at the start of April

PETE LAWRENCE X 2, ISTOCK X 7, NASA X 4

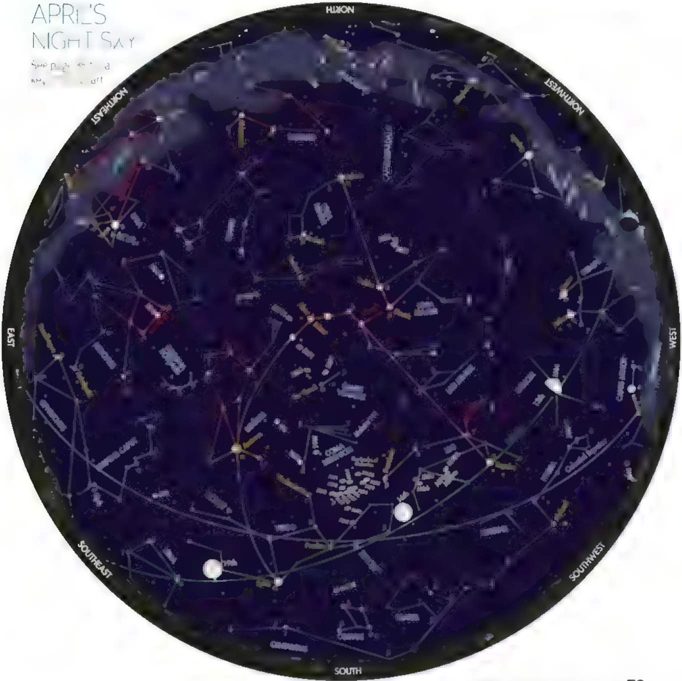
Spica is the brightest star in Virgo the Virgin, the second largest constellation in the night sky. The largest is **Hydra the Watersnake** which slithers south of Virgo. Between the western region of Virgo and the Snake's body sit two small constellations known as Crater the Cup and Corvus the Crow. Crater has a faint but distinctive shape but requires dark skies to see properly. Corvus is smaller and brighter. It contains an asterism known as the Sail because being of low altitude it resembles a sailing boat's sail drifting along the horizon.

The star in the southeast corner of the Sail is Kraz (Beta (β) Corvi). If you draw a line between Kraz and Porrima (Gamma (γ) Virginis), the star at the bottom of the large asterism known as the Bowl of Virgo, at the mid-point is the small but distinctively shaped **M104**, the Sombrero Galaxy. Larger instruments will detect a dark dust lane passing across its longest dimension.

A new Moon will leave the start of April good and dark – a perfect time to look to the west after sunset to try to see the dim conical glow of the **zodiacal light**. This represents sunlight scattered by dust in the plane of the Solar System. You'll need to find a dark site to make your attempt. Typically, the best time to start looking is 90 minutes after sunset.

APRIL'S NIGHT SKY

[illegible] a key [illegible] chart



May

Dark skies could make for exciting Aquariids and M5 is well placed mid-month

6 MAY
Eta Aquariid meteor shower reaches its peak this morning

11 MAY
Lunar X and V will be visible at 17:45 UT

20 MAY
Moon close to Jupiter as darkness falls

26 MAY
Approximate start of the noctilucent cloud season

28 MAY
Ceres reaches opposition on Ophiuchus-Scorpius border

Comet C/2016 R2 (PANSTARRS) & the Pleiades

José J Chambó, New Mexico, US, 4 February 2018

HOTSHOTS WINNER MAY 2018

May

It's during May that the nights really appear noticeably shorter. Certainly by the end of the month, it can seem that no sooner have you set up for night observing than dawn twilight starts to appear, an effect that's worse the further north you are in the UK. Despite this, there are still plenty of things to look out for.

The bright orange star **Arcturus** (Alpha (α) Boötis) is very evident indeed. It sits at the southern 'pointed' end of a large kite-shaped asterism. Being as high as the Saucepan is long, the Kite represents the main body of Boötes the Herdsman. For such a large constellation it's somewhat surprisingly devoid of deep-sky objects, but does contain a number of impressive double stars. Turn to page 62 for more details on these.

Running between Boötes and Ursa Minor, the Little Bear, is the winding constellation of **Draco the Dragon**. The Dragon's head is marked by a distinctive quadrilateral pattern of stars known as the Lozenge.

East of Boötes is the lovely compact constellation of Corona Borealis, the **Northern Crown**. This is a small semi-circle of stars, often described as a backward C. Its brightest star is Gemma (Alpha (α) Coronae Borealis), the 'jewel' in the crown. The inside of the semi-circular crown is, to the naked eye, devoid of stars unless you're lucky enough to catch an irregular variable known as **R Coronae Borealis** at peak brightness. This remarkable star is carbon rich. Sooty deposits build around it, blocking its light so it dims and appears quite red. Over time the soot clears, allowing R to increase in brightness once again. This has earned R the informal name the 'Dust Puff Star'. If it is visible it'll be right on the edge of naked eye visibility from a dark-sky site.

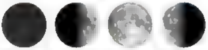
Southeast of Corona Borealis is the zig-zag shape of **Serpens the Serpent**. Serpens is unique in the heavens in that it's split in two. The head is represented by Serpens Caput and the tail by Serpens Cauda. Serpens is being carried across the sky by the constellation Ophiuchus the Serpent Bearer. It is Serpens Caput that lies west of Ophiuchus and southeast of Corona Borealis. The magnificent globular cluster **M5** is located between Serpens Caput and the northeast corner of Virgo. It's conveniently located very close to the faint star 5 Serpentis. Find this star and you'll find M5.

Tracking magnificent M5

One way to locate M5 is to use the constellation of **Libra the Scales** which lies to the south. The two brightest stars in Libra – Zubenelgenubi (Alpha (α) Librae) and Zubeneschamali (Beta (β) Librae) – form what's best described as a 45° line in the sky. Imagine Zubeneschamali as the centre of a three-pronged steering wheel, with Zubenelgenubi as the star marking the

MOON PHASES

Key stages in the monthly cycle



4 May | 12 May | [illegible] May | 26 May

VISIBLE PLANETS

Where to spot the planets this month

[illegible]
Morning planet for most of May but best in evening sky at the end of the month.

[illegible]
Bright morning planet, poorly positioned. Best seen at the end of the month.

[illegible]
Evening planet compromised by twilight. Appears against the northeast edge of M35 on 19 May.

[illegible]
Bright object in southern Ophiuchus. Low from the UK, only reaching altitude of 15°.

[illegible]
Morning object in Sagittarius. Bright 82% waning gibbous Moon 2.1° southeast of Saturn on 23 May.

[illegible]
Not visible

[illegible]
Not visible

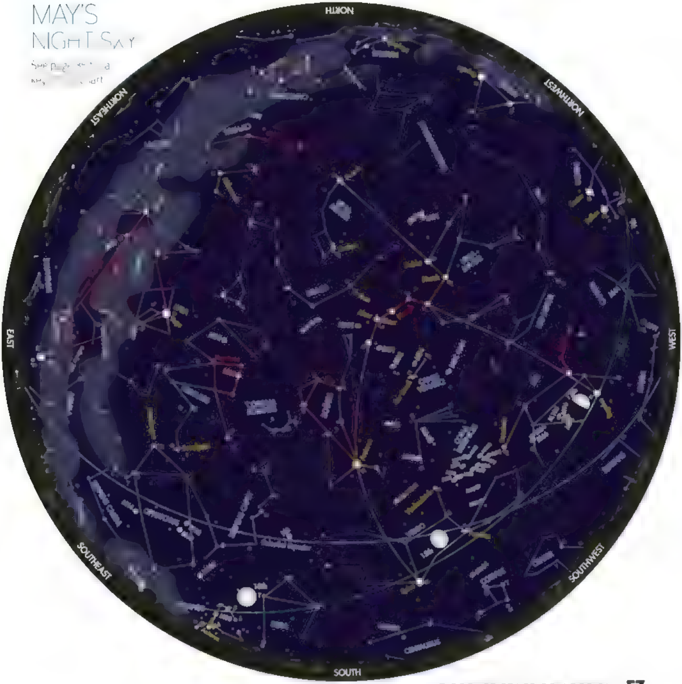
Ceres reaches opposition on May 28 and is located relatively close to Jupiter all month

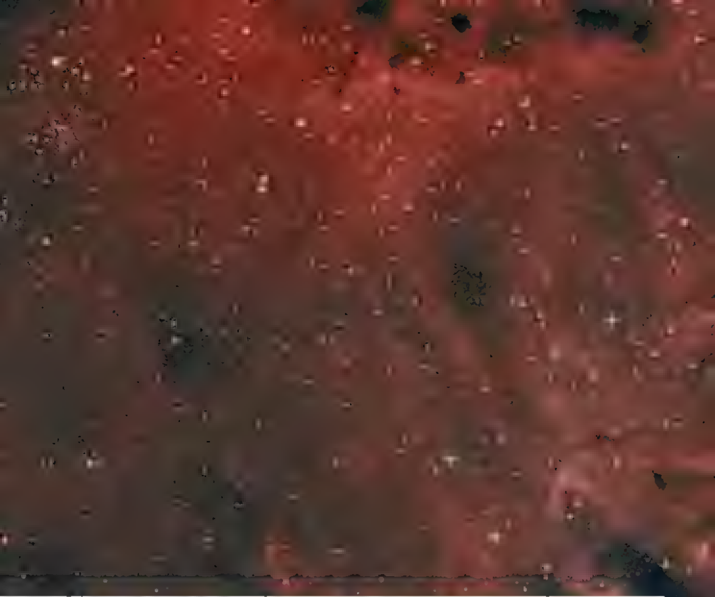
end of the bottom-left spoke. M5 would be just to the north of where you'd imagine the top spoke to end.

The dark moonless skies at the start of May are ideal for watching the peak of the **Eta Aquariid meteor shower**, which has a ZHR of 40 meteors per hour at peak on the morning of 6 May. Daylight doesn't need to halt observing either, and the lighting effects known as the **Lunar X and V** reach their peak in the afternoon of 11 May, when a giant letter X may be seen using a telescope approximately 1/3rd the way up the terminator from the south point at 17:45 UT. The V is about 3/5ths of the way up the terminator.

MAY'S NIGHT SKY

See page [illegible] a key [illegible] chart





June

Jupiter and the Moon keep company as giants Hercules and Ophiucus dominate

ALL MONTH
Noctilucent cloud spotting season

8 JUNE
Europa and its shadow transit virtually aligned

10 JUNE
Jupiter reaches opposition

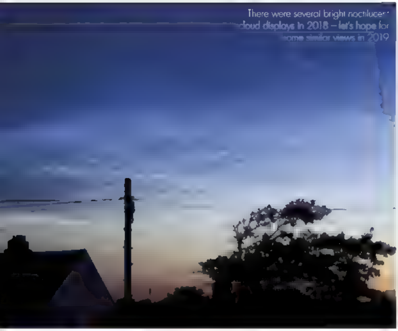
15 JUNE
Almost full Moon, Jupiter and Antares are nicely grouped

28 JUNE
Peak of the June Bootids, with low activity expected

The Cone Nebula and the Christmas Tree Cluster

Ian J Crichton, Dalgety Bay, Fife 7 February 2018

HOTSHOTS WINNER, JUNE 2019



There were several bright noctilucent cloud displays in 2018 – let's hope for some similar views in 2019

June

MOON PHASES

Key stages in the monthly cycle

3 Jun | 10 Jun | 17 Jun | 25 Jun

VISIBLE PLANETS

Where to spot the planets this month

MERCURY
Greatest eastern (evening) elongation of 25.2° on 23 June. Near Mars on 18 June

VENUS
Morning object rising 45 minutes before the Sun all month

MARS
Poorly positioned evening planet appearing close to Mercury on the evenings of 17–19 June

JUPITER
Reaches opposition on 10 June. Rather low as seen from the UK

SATURN
Morning planet visible to the east of the Teapot in Sagittarius

URANUS
Not visible

NEPTUNE
Tricky morning planet. Possibly visible close to Phi (φ) Aquarii towards the end of June

June is a testing month for UK astronomy because the nights are so short. A number of less distinct constellations try to take centre stage, but close on their heels are the strong patterns of summer. The view to the south is dominated, if that's the correct term, by two giants of the night sky: **Hercules the Strongman** and **Ophiuchus the Serpent Bearer**. Hercules is a faint constellation but redeemed by an asterism known as the Keystone. This is formed from Epsilon (ε), Zeta (ζ), Eta (η) and Pi (π) Herculis.

Although the Keystone is not particularly bright, its shape does stand out rather well and acts as a guide for finding the Great Globular in Hercules, **M13**. This globular cluster sits one-third along the side of the Keystone from Eta toward Zeta Herculis. It's a really magnificent example, containing around 100,000 to 1 million stars, packed into a spherical volume just 145 lightyears in diameter.

The head of Hercules is located at the southern extremity of the constellation, marked by the star Rasalgethi (Alpha (α) Herculis). Hercules is upside down in UK skies, his head located close to the head of our second giant, Ophiuchus. The Serpent Bearer's head is represented by Rasalhague (Alpha (α) Ophiuchi). From there the main body of the constellation appears to the south as a box shape that some have likened to an upturned flowerpot. Two legs dangle from the southern corners of the box, with bright Jupiter currently wandering through this area.

Ophiuchus contains a number of interesting globulars, including M10, M12 and M19. His eastern shoulder plays host to IC 4665, a large and relatively bright open cluster 1.3° north of Cebalrai (Beta (β) Ophiuchi). Look 4.5° east of Cebalrai and, given clear skies, you should be able to see a faint V pattern of stars. This is known as **Poniatowski's Bull**. Barnard's Star sits west-northwest of the star, marking the end of the western arm of the V (66 Ophiuchi). **Barnard's Star** has the largest measured

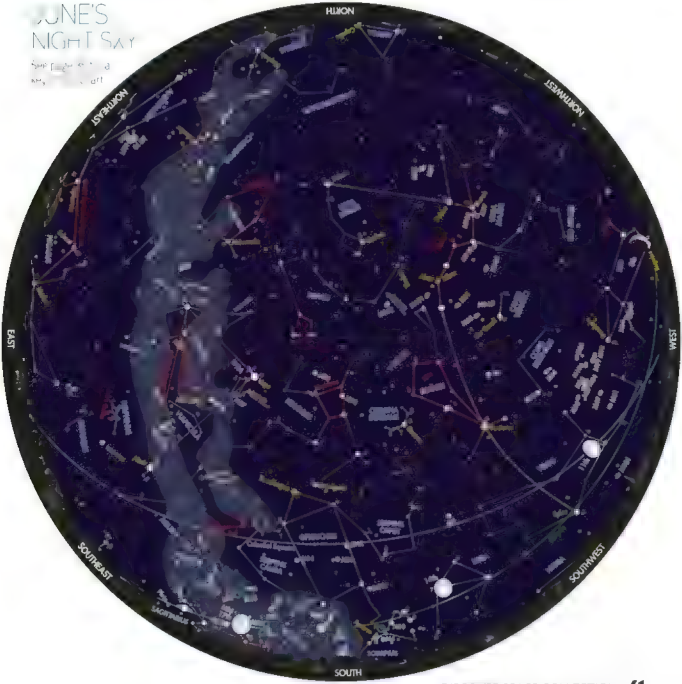
PETE LAWRENCE X 3, ISTOCK X 7, NASA X 4

proper motion in the entire sky, moving roughly half the apparent diameter of the Moon against the fixed background sky every 90 years. At mag. +9.5, a telescope is required to see Barnard's Star

Below Ophiuchus's western leg is bright orange **Antares** (Alpha (α) Scorpii), the star marking the heart of Scorpius the Scorpion The binocular globular cluster, **M4** sits 1.3° west of Antares. The region east of the star takes us into a very rich part of the Milky Way – the plane of our own home Galaxy, represented by a misty path formed from the integrated light of billions of distant stars. The region immediately east of Antares is the part of the Milky Way we see marking the direction of the bright core of our Galaxy

In the same general region as Antares is **Jupiter**, which on 10 June is at opposition (in the opposite part of the sky to the Sun). On the evening of 16 June the Moon is also at opposition, and can be seen very close to Jupiter. June is also a good time to see **noctilucent clouds**. Look out 90–120 minutes after sunset low above the northwest horizon or a similar time before sunrise, low above the northeast horizon. They appear with an electric blue colour often with a fine wispy structure glowing against the dark of night

JUNE'S NIGHT SKY




HERCULES
URSA MAJOR
M101
Alcor
Mizar
Quadrantid radiant during shower peak 3/4 Jan
June Boötid radiant during shower peak 26/27 Jun
Alkaid
M51
BOÖTES
Nekkar
CORONA BOREALIS
Alkalurops
Seginus
CANES VENATICI
Nusakan
Gemma
Izar
NGC 5466
M3
SERPENS CAPUT
Arcturus
Muphrid
NGC 5453
M53
COMA BERENICES
VIRGO

SPRING: Boötes

The constellation Bootes the Herdsman has various myths associated with it. In one it represents Arcas, the illegitimate son of Zeus and Callisto. Angered by Zeus's infidelity, his wife Hera turned Callisto into a bear. When Arcas came face-to-face with his mother in the woods he drew an arrow to shoot her before Zeus intervened and turned Arcas into a bear. Grabbing mother and son he swung them with such ferocity their tails stretched and they ended up in the heavens as Ursa Major and Ursa Minor, the Great and Little Bears. The Greek name for Boötes is Arctophylax, which means 'Bear Watcher'.

Bootes is a large kite-shaped constellation. Its primary star is Arcturus (Alpha (α) Boötis), the fourth brightest nighttime star, which shines with a distinct orange colour. Arcturus has the largest proper motion of all the first-magnitude stars, with the exception of Alpha Centauri. It appears to move 2.29 arcseconds a year relative to the stellar background.

The asterism that forms the main body of the herdsman is 23.5° high, extending north-northeast from Arcturus. Another, considerably smaller and fainter, small telescope asterism, Picot 1 can be found half a degree south-southwest of Arcturus and is formed from seven stars around 10th magnitude that depict the profile of Napolean's hat!

There is a surprising lack of deep-sky objects in Boötes. The most conspicuous include the mag. +10.5 globular cluster NGC 5466, the mag. +10.2 spiral galaxy NGC 5248 and the mag. +10.9 spiral galaxy NGC 5676. However, there's an empty expanse of space in this direction known enigmatically as the Boötes Void. This roughly spherical region of the Universe measures 330 million lightyears in diameter and contains hardly any galaxies. The centre of the void lies 700 million lightyears from the Sun.

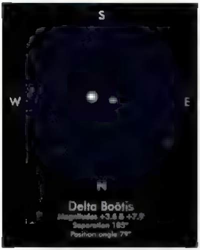
Arcturus's beautiful companions

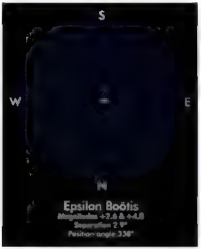
One thing Boötes does excel at is multiple stars, many of which are easy to split with binoculars or a small telescope. Highlights here include Delta (δ) Boötis which is very easy as a mag. +3.6/+7.9 pair separated by 103.8 arcseconds. Kappa (κ) Boötis is harder with magnitude +4.6/+6.6 components separated by 13.5 arcseconds. A low-power eyepiece also allows Iota (ι) Boötis to be viewed in the same field as Kappa, with mag. +4.8/+7.4 components separated by 38.7 arcseconds.

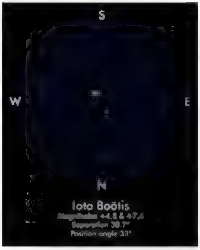
Pi (π) Boötis is a lovely tight double with component magnitudes of +4.9/+5.8 separated by 5.5 arcseconds. Xi (Ξ) Boötis is another worthy target, showing as a yellow and orange pairing of mag. +4.8/+7.0 stars separated by 6.3 arcseconds.

Izar (Epsilon (ε) Boötis) shows an unequal mag. +2.6/+4.8 pair separated by a narrow 2.9 arcseconds. You'll need a 75mm or larger scope to split Izar but the effort is well worth it as they shine with golden-yellow and blue colours.

Boötes plays host to several annual meteor shower radiants. The most famous are the Quadrantids, with a peak on 3/4 January with a ZHR of 120 meteors per hour and favoured by a new Moon on 6 January.







ALL PICTURES: PETE LAWRENCE

July

The nights may be short but Saturn's rings shine brighter than normal this month

ALL MONTH
Noctilucent clouds

9 JULY
Saturn reaches opposition

14 JULY
Pluto reaches opposition [illegible]
3° [illegible] Sagittarii

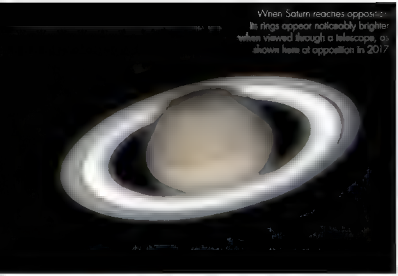
16 JULY
Partial lunar eclipse

29 JULY
Peak of the Southern Delta
Aquariid meteor shower

Star trails at La Silla

Zdeněk Bardon, La Silla Observatory, Chile, 14 March 2018

HOTSHOTS WINNER JULY 2018



When Saturn reaches opposition its rings appear noticeably brighter when viewed through a telescope, as shown here at opposition in 2017

July

The bright, vibrant constellations of summer now take their place centre stage towards the south. The most prominent pattern on view is that of the giant asterism known as the **Summer Triangle**. Formed from the three brightest stars in Cygnus, Lyra and Aquila – respectively Deneb (Alpha (α) Cygni), Vega (Alpha (α) Lyrae) and Altair (Alpha (α) Aquilae) – the Triangle plays host to a bright section of the summer Milky Way.

Imagining the Summer Triangle to be pointing down towards the horizon, slightly west of the region it's pointing at sits another distinctive pattern of summer – the **Teapot** asterism. This is part of Sagittarius the Archer and really does look like its name suggests. The spout off to the west marks the approximate position of the centre of our Milky Way Galaxy.

It's a very worthwhile exercise scanning the region where you'd expect steam to be rising out of the Teapot's spout. Here you'll find exotic objects such as **M8 the Lagoon Nebula** and **M20 the Trifid Nebula**. Both sit well within a binocular view, providing a great opportunity to compare their appearance. The Lagoon is expansive and bright, while the more distant Trifid appears dim and compact. Additional rewards in the area include the rich open cluster **M25** and equally resplendent globular cluster **M22**.

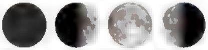
North of the Teapot is multi-titled **M17**, also known as the Swan, Lobster, Omega and Horseshoe Nebula. Between M17 and M20 you'll find the large rich star-cloud known as **M24** or Delle Caustiche.

North of M17 is **M16 the Eagle Nebula**. This can be a frustrating object, showing as a beautiful glowing gas cloud through long-exposure photography. It's here that the shape of a spread-winged eagle appears. However, visually through the eyepiece the nebula is often missing, leaving only the star cluster at the heart of M16. Larger apertures will show it, but it's much fainter than photographs would suggest.

M16 is technically within the constellation of Serpens Cauda, the Serpent's Tail, lying close to the border with **Scutum the Shield**. This is another rich deep-sky region thanks again to the presence

MOON PHASES

Key stages in the monthly cycle



VISIBLE PLANETS

Where to spot the planets this month

MERCURY
Not particularly well placed all month

VENUS
Bright morning planet but close to the Sun. Moon near on the morning of 1 and 31 July.

MARS
Evening planet lost from view this month

JUPITER
Bright planet, well placed but low as seen from the UK

SATURN
Reaches opposition on 9 July. Rings brighten leading up to opposition, fading in the days after

URANUS
Uranus is a morning planet best seen towards the end of July

NEPTUNE
Neptune is a morning planet. Its position improves throughout the month

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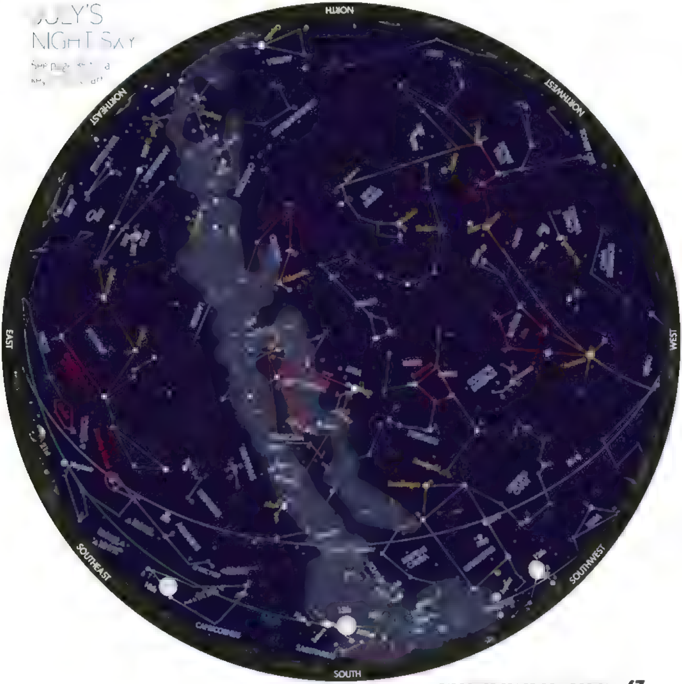
of the Milky Way Scutum looks like a narrow diamond of stars oriented northeast/southwest. Its northern extreme lies close to the 'tail' of **Aquila** a region marked by a gentle curve of faint stars. The curve conveniently runs towards **M11 the Wild Duck Cluster** one of the richest and most impressive open clusters in the entire night sky.

The planet **Saturn** is currently located in Sagittarius, just south of another asterism known as the Teaspoon itself located northeast of the Teapot. Saturn reaches opposition on 9 July and in the days running up to this date it's worth taking a look at the planet through a telescope. The rings brighten in the days before opposition and fade back to normal in the days that follow an optical phenomenon known as the Opposition Effect.

Six months on from the total lunar eclipse at the start of the year, another **lunar eclipse** is set to occur on 16 July. Unlike the one in the early hours of 21 January, this month's eclipse will be a partial, just beginning as the Sun sets and the Moon rises on the evening of 16 July. Maximum eclipse occurs at 21:31 UT when the Earth's shadow will encroach to cover 65 per cent of the Moon's apparent diameter.

JULY'S NIGHT SKY



Centaurus A ▷

Fernando Oliveira De Menezes, Sao Paulo, Brazil, 18 May 2018

HOTSHOTS WINNER AUGUST 2018

August

All eyes on Lyra, Cygnus, Aquila and bright Jupiter for Ganymede's shadow transit

1 AUGUST
Mars lies just south of an ultrathin lunar crescent after sunset

13 AUGUST
Perseid meteor shower peaks under bright Moonlight

22 AUGUST
Ganymede's shadow transits Jupiter from 19:18 UT

26/27 AUGUST
Jupiter passes across globular cluster NGC 6235 in Ophiuchus

30 AUGUST
Thin morning Moon with Mercury nearby

Looking east-northeast 30 August approximately 30 minutes before sunrise (simulated 7x50 binocular view)

August

August is an exciting month. As the nights start to lengthen, the sky views on offer are nothing short of breathtaking. Stars and constellations which were so tantalisingly on offer during July's short nights slowly drift to the west as the retreating evening twilight gives us longer to look at them.

The **Summer Triangle** is now very dominant high in the south. Its vertex stars, Deneb, Vega and Altair are very obvious. Vega (Alpha (α) Lyrae) in the northwest is the visually brightest of the three. For a long time this was the star that marked the zero point on the magnitude scale used to describe star and object brightness. Its host constellation is **Lyra the Harp**. This is a compact affair best defined by the squashed diamond pattern of fainter stars that 'hangs' south of Vega. The two stars at the base of the pattern, Sheliak (Beta (β) Lyrae) and Sulafat (Gamma (γ) Lyrae), provide a convenient method for locating a showpiece of the summer skies, the **Ring Nebula M57**. This object, representing the outer layers of a low-mass dying star ejected off into space, sits slightly offset towards Sheliak from the mid-point of the line between both

PETE LAWRENCE X 3, ISTOCK X 7, NASA X 4

MOON PHASES

Key stages in the monthly cycle

1 Aug | 7 Aug | 15 [illegible] | 23 Aug | 30 Aug

VISIBLE PLANETS

Where to spot the planets this month

[illegible]
Morning object at greatest western elongation on 9 August. Lost from view after 24 August

[illegible]
Not visible

[illegible]
Near a very thin waxing crescent Moon on 1 August, but soon becomes lost from view

[illegible]
Low evening planet. A 72% lit waxing crescent Moon lies close on 9 August.

[illegible]
Evening planet in Sagittarius positioned under the Teaspoon

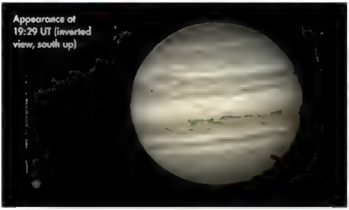
[illegible]
Improving morning planet on the verge of naked eye visibility

[illegible]
Morning planet best seen towards the end of the month close to Phi (φ) Aquarii

stars. It's also a fraction south of the line. Through a telescope, M57 is easily overlooked as a faint star at low magnification, but as the power is piled on, its extended disc is most evident.

Seeing doubles in Lyra

Vega marks one point of an equilateral triangle, with Zeta (ζ) and Epsilon (ε) marking the other vertices. Look hard at Epsilon to the north and see if you can split it into two stars. Through a telescope the double nature is very evident, but there's a further twist because each of the components is double again. The extra doubling can be hard to see at first, good optics and a reasonable magnification being required. This physica



Appearance at 19:29 UT (inverted view, south up)

aspect of the Epsilon Lyrae system has given it the name the Double-Double.

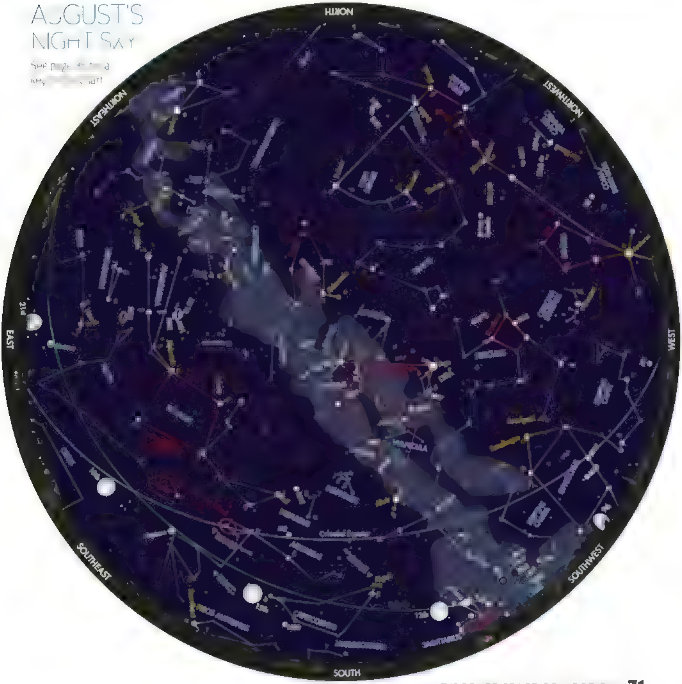
As we're describing doubles, one of the most beautiful in the entire sky lies at the southern end of a large asterism known as the Northern Cross. **Albireo** (Beta (β) Cygni) is a glorious sight through a telescope, presenting a golden-yellow primary and azure blue secondary. It marks the head of **Cygnus**, a constellation that represents a swan flying across the night sky. It's an easily identified pattern rich in deep sky wonders. Turn to page 76 to find out more about it.

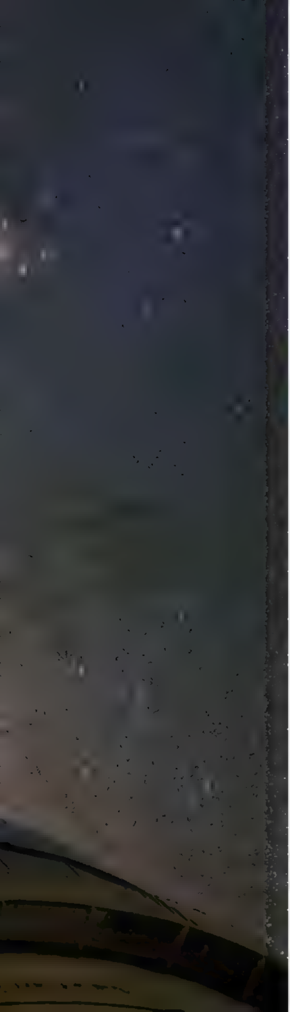
This month there are two thin Moon-spotting opportunities, a tricky one after sunset on 1 August and one before sunrise on 30 August. Both have planets nearby, Mars on the 1st and Mercury on the 30th, which should make finding these thin slivers a little easier.

Another planetary event worth noting is the apparent passage of **Jupiter** in front of the globular cluster NGC 6235 in Ophiuchus. The globular has an apparent size of 5 arcminutes, eight times larger than the apparent size of the planet. Jupiter's brightness will be an issue, but astrophotography may be able to reveal this unusual conjunction visible in the early evening sky of 26 and 27 August.

AUGUST'S NIGHT SKY

See page [illegible] a key [illegible] chart





◁ The Milky Way

Guillaume Doyen, Cerro Tololo Inter-American Observatory, Chile, 13 June 2018

HOTSHOTS WINNER SEPTEMBER 2018

September

Plenty of evening viewing this month, and Neptune skips past red giant Phi Aquarii

5 SEPTEMBER
Mag. +7.8 Neptune is 30 arcseconds from star Phi Aquarii

10 SEPTEMBER
Neptune reaches opposition

13 SEPTEMBER
Mag. –0.9 Mercury is just 18.6 arcminutes from –3.8 Venus after sunset

14 SEPTEMBER
Harvest Moon

23 SEPTEMBER
The northern hemisphere's autumn equinox occurs at 07:50 UT

September

MOON PHASES
Key stages in the monthly cycle

6 Sep | 14 Sep | 2[illegible] Sep | 28 Sep

VISIBLE PLANETS
Where to spot the planets this month

MERCURY
After superior conjunction on 4 September emerges into a poor position in the evening sky

VENUS
Evening object close to the Sun. A 1% waxing Moon is 3.3° above Venus on 29 September

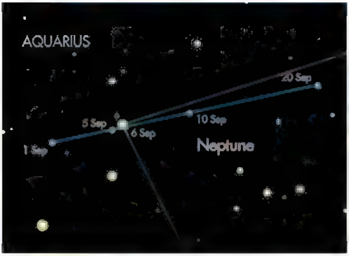
MARS
Not visible.

JUPITER
Bright Jupiter is an evening planet but rather low

SATURN
Evening object in Sagittarius. A 76% lit waxing gibbous Moon is nearby on 8 September

URANUS
Currently the best positioned planet, reaching 50° altitude in darkness when due south

NEPTUNE
Neptune reaches opposition on 10 September. Very close to Phi (φ) Aquarii on 6 September



The nights really start to draw in quickly during September, an effect caused by the apparent southward motion of the Sun reaching a peak rate for the year. The peak occurs at the September equinox, also known as the northern hemisphere's autumn equinox. This is an instant when the centre of the Sun's disc crosses the projection of Earth's equator into the sky, a great circle known as the celestial equator.

There's a certain excitement to the sky at this time of year because dark nights are back on the cards. The stars of summer remain well placed, with the **Summer Triangle** still in a dominant southerly position early evening. The integrated light of billions of stars in our own Galaxy forms the misty path known as the **Milky Way** and this can be seen, from a dark-sky location, flowing down through the triangle. A detached patch of Milky Way close to the bottom of the constellation of **Aquila the Eagle** is renowned for tricking sky watchers into thinking clouds are starting to appear. Known as the **Scutum Star Cloud**, this bright, heart-shaped patch of Milky Way is very evident from a dark-sky site.

The brightest star in Aquila is Altair (Alpha (α) Aquilae). It marks the bottom vertex of the Summer Triangle and is easy to identify because it has two dimmer stars either side of it: Alshain (Beta (β) Aquilae) and Tarazed (Gamma (γ) Aquilae).

A fox, an arrow and a dolphin
The region to the north of Aquila is populated by small constellations, some well-defined, others frankly obscure. At the foot of the Northern Cross, near to the beautiful binary star Albireo (Beta (β) Cygni) we start at the obscure end of the spectrum with the very faint and rather loose form of **Vulpecula the Fox**. Despite its ill-defined nature, there are a number of interesting objects to view here.

Brocchi's Cluster, Collinder 399, is located in the southern part of the constellation, 4.5° south of Alpha (α) Vulpeculae. The stars here form the shape of a coat hanger, giving the object the informal name the Coathanger Cluster. You can just about see the coat hanger shape with the naked eye, but you're not looking at a true cluster here as Collinder 399 is an asterism, a chance alignment of stars.

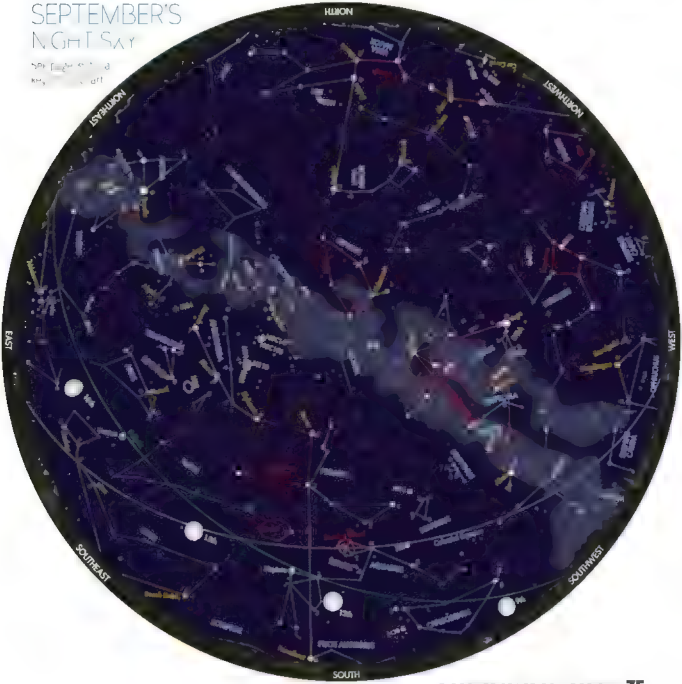
The beautiful planetary nebula **M27, the Dumbbell Nebula**, appears to the east-northeast of Collinder 399. Visible in binoculars, this object takes on the appearance of an apple core when seen through the eyepiece of a telescope. A good way to locate it is to use another small constellation found south of

Vulpecula. **Sagitta the Arrow** has better definition than Vulpecula and is actually shaped like an arrow. Locate the star Delta (δ) Sagittae which marks the point where the shaft meets the flight of the arrow. Imagine the line from Delta to Gamma (γ) Sagittae, which is at the pointed end of the arrow's shaft. Rotate the line for 120° around Gamma in a counter-clockwise fashion. Where Delta would end up marks the position of M27.

East-southeast of Sagitta is the small and distinctive constellation of **Delphinus the Dolphin**. It looks like a tight diamond of stars with a tail, representing the nose and neck of a bottlenose dolphin. An interesting fact about Delphinus is that it contains the star Rho (ρ) Aquilae. Since this star was labelled as part of the constellation of Aquila, its apparent motion in the sky has made it drift slightly across the border between Aquila and Delphinus, so it's now in the wrong constellation!

The line of small constellations ends as it began with the small and rather obscure constellation of **Equuleus the Foal**. Its four faint stars nestle up against another equine pattern, the autumn constellation of **Pegasus the Flying Horse**.

SEPTEMBER'S NIGHT SKY



DRACO
CEPHEUS
Alderamin
NGC 7160
NGC 7261
NGC 6939
NGC 6946
CYGNUS
LYRA
VULPECULA
PEGASUS
Deneb
Sadr
Gienah
Albireo
M39
NGC 7062
IC 5067
IC 5070
Northern Coalsack
NGC 6910
M29
NGC 6826
NGC 6866
NGC 6871
Veil Nebula Complex

SUMMER: Cygnus

Cygnus the Swan flies high above UK skies during the summer. Its central pattern, the large and easily identified asterism known as the Northern Cross, represents the tail, body and wing-stubs of the Swan.

Myth tells of Cycnus and Phaethon, the son of the Sun god Helios, racing across the heavens. Venturing too close to the Sun, their chariots burned up and fell to Earth. Phaethon fell in the river Eridanus and drowned. Cycnus survived and asked Zeus to turn him into a swan so he could retrieve his friend. Zeus was so moved by this that he placed Cycnus in the heavens.

Bright Deneb (Alpha (α) Cygni) sits on top of the cross with dimmer Albireo (Beta (β) Cygni) at the base. Deneb represents the bird's tail, and Albireo, a beautiful binary, its beak. Although Deneb appears outshone by the other two triangle stars, Vega (Alpha (α) Lyrae) and Altair (Alpha (α) Aquilae), that's because they are only 25 and 17 lightyears away. At an estimated 2,500 lightyears distance, Deneb is far brighter, around 200,000 times more luminous than the Sun and 200 times larger.

Riches of the deep sky

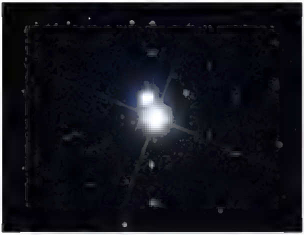
The presence of the Milky Way gives Cygnus a rich repository of deep-sky objects. Long exposures reveal extensive glowing hydrogen in the region, with one popular imaging area surrounding the Northern Cross's central star, Sadr (Gamma (γ) Cygni).

The star Eta (η) Cygni, sits halfway between Sadr and Albireo. Close to it is an exotic object, Cygnus X-1, a strong X-ray source and the first accepted to be directly related to a black hole. You can't see the black hole, but it is possible to see the ninth-magnitude star HDE 226868 with which it is in mutual orbit.

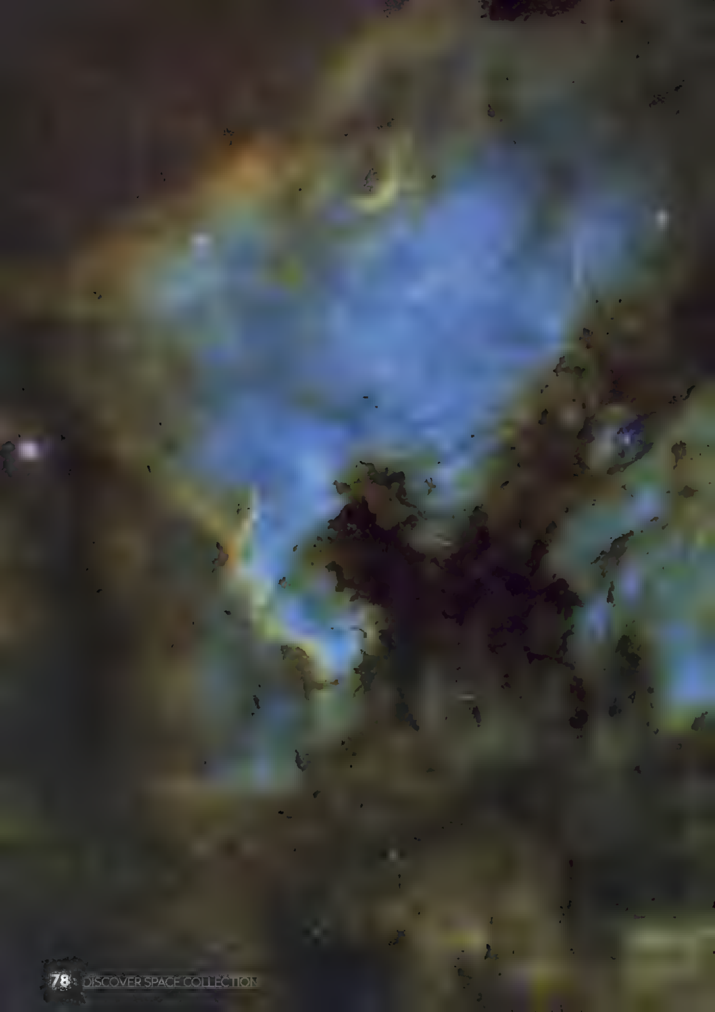
Surprisingly, Cygnus only contains two Messier objects, both open clusters. M29 is located 1.8° south of Sadr and is rather underwhelming, its box shape earning it the nickname the Cooling Tower Cluster. M39 is more impressive. Sitting 2.9° north of mag. +4.0 Rho (ρ) Cygni, this triangular-shaped cluster stands out well against the Milky Way background. A line extended from nearby Pi-1 (π^1) through Pi-2 (π^2) Cygni brings you to the Cocoon Nebula Sh2-126, associated with the embedded open cluster IC 5146. Astrophotography reveals a striking feature of the surrounding area, the dark nebula B168 that forms a 'lane' towards the Cocoon.

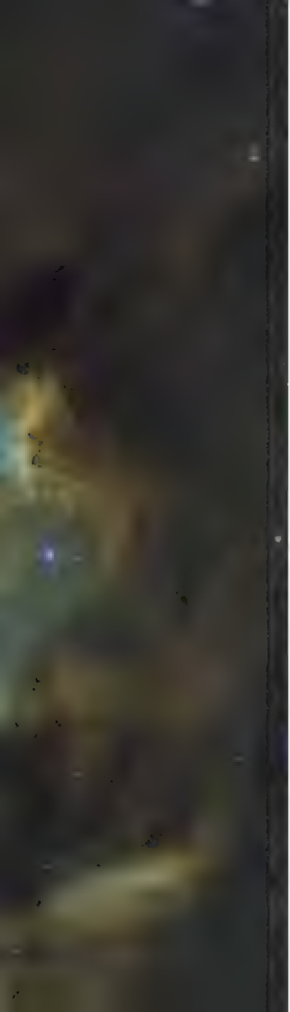
Another famous patch of nebulosity sits 2.3° east of Deneb. Known as the North America Nebula, NGC 7000, this 120x100 arcminute patch of glowing hydrogen is best seen with the naked eye from a dark-sky location. It's another popular photographic target, long exposures revealing its pink-red colour and the fact that it really does resemble the outline of North America. Immediately to its west is IC5067/70, the Pelican Nebula, another popular photographic target, which resembles the profile of a pelican's head.

Switching to the western wing, you'll find the Blinking Nebula, NGC 6826. This 10th-magnitude planetary nebula gets its name because if you look directly at its central star, the star's brightness overwhelms the surrounding nebulosity, causing it to disappear. Look slightly to the side of the object using the technique of averted vision, and the nebulosity magically reappears.



ALL PICTURES: PETE LAWRENCE





◁ The North America Nebula

Reza Hakimi, [illegible], on 10–11 July 2018

HOTSHOTS WINNER OCTOBER 2018

October

There are stunning views in October's skies as several galaxies become favourable

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3 OCTOBER
Moon very close to Jupiter this evening

8 OCTOBER
Moon's Jewelled Handle effect visible at 17:45 UT

10 OCTOBER
Southern Taurid meteor shower reaches its peak

21 OCTOBER
Peak of the Orionid meteor shower this evening

31 OCTOBER
Jupiter sits 24 arcminutes south of the Moon's centre in daylight

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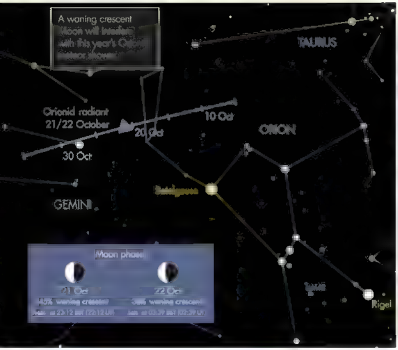


October

MOON PHASES

Key stages in the monthly cycle

5 Oct | 14 | Oct | 28 Oct

VISIBLE PLANETS

Where to spot the planets this month

MERCURY
Reaches greatest eastern (evening) elongation on 20 October but is poorly placed all month

VENUS
Slowly drawing from the Sun into the evening sky. Best seen at the end of October

MARS
Morning object slowly separating from the Sun. Telescopically rather tiny

JUPITER
Observing window is closing

Waxing crescent Moon nearby on the evenings of 3 and 31 October

SATURN
Evening planet Saturn has a close visit from the first quarter Moon on 5 October

URANUS
Uranus reaches opposition on 28 October and is visible all night long

NEPTUNE
Well placed as an evening planet in Aquarius, close to the star Phi (φ) Aquarii

The October night sky can be thrilling. In the early evening there are the constellations of autumn, led across the sky by **Pegasus the Flying Horse**. These are followed by the dramatic constellations of winter which dominate the morning sky.

The **Great Square of Pegasus** is prominent early evening. This is a large asterism formed from four medium-bright stars. Despite the name, none of the square's sides have equal length. Across the top it is 12° wide while at the bottom it is 17° wide. The sides are more even at 13° on the west and 14° on the east. For comparison, your fist at arm's length is about 10° wide.

The number of stars seen within the square reveals your sky clarity. A count of zero means your sky is poor and probably light-polluted. An average UK sky should reveal at least five stars. A dozen or more indicates particularly good skies, but is way off the theoretical maximum of 35 stars. If you can count this many then your sky is quite exceptional.

The Great Square is a starting point for locating the **Andromeda Galaxy, M31.** Extend a line from Scheat (Beta (β) Pegasi) in the northwest corner through Alpheratz (Alpha (α) Andromedae) in the northeast. Keep going for the same distance again, bending north as you go to arrive at medium-bright Mirach (Beta (β) Andromedae). Turn 90° to move up the sky and reach Mu (μ) Andromedae. Keep going to locate dimmer Nu (ν) Andromedae and M31 is the elongated fuzzy patch just west of this star.

M31 is the furthest object you can see with the naked eye from a typical dark site, a spiral galaxy around 2.5 million lightyears away. What you're looking at here is just the bright core of the galaxy. Binoculars or a small telescope should reveal M31's two closest satellite galaxies. Relative to the core of M31, M32 sits 0.5° to its south, while the M110 lies 1.6° to the northwest.

The hero and the blinking demon

You can use M31 to locate **M33 the Triangulum Galaxy**. Extend a line from M31 through Mirach for the same distance again to arrive at M33. This is slightly further away at 3 million lightyears and much harder to see because it's virtually face on to us, resulting in low surface brightness. The core is brightest and can be seen with binoculars or a small telescope, or even with the naked eye from an exceptionally dark site.

Wedge-shaped Andromeda stretches east towards her mythological rescuer and husband, **Perseus**.

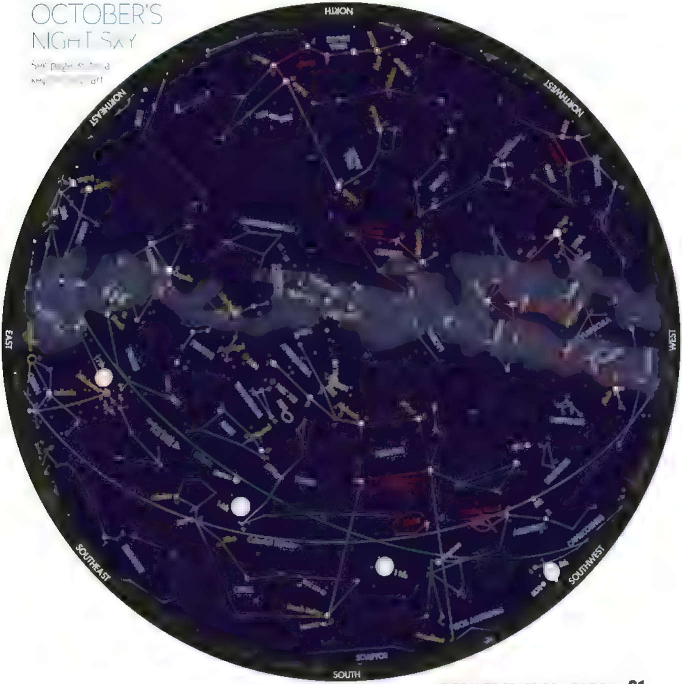
the Greek Hero. Its brightest member is the white-yellow supergiant Mirphak (Alpha (α) Persei), sitting in a semicircle of fainter stars. Many of these are associated, belonging to the **Alpha Persei Cluster** or Melotte 20

South of Mirphak lies the eclipsing binary Algol (Beta (β) Persei), also known as the **Demon Star**. This is a system where two mutually orbiting stars appear to eclipse one another as seen from Earth. When Algol's brighter primary is eclipsed by the dimmer secondary we see a dip of 1.3 magnitudes. When the brighter star eclipses the dimmer one, the dip is so shallow that specialist equipment is needed to detect it. The primary eclipses last for around nine hours and occur every two days, 20 hours and 49 minutes

To the north of Andromeda you'll find her mother **Queen Cassiopeia**, the easily identified W-shaped constellation. Drawing an imaginary line between the central star of the W, Gamma (γ) Cassiopeiae, and Mirphak in Perseus, halfway along its length you'll find two beautiful open clusters, NGC 884 and 869 known as the **Double Cluster**. With dark conditions, binoculars or a telescope on a low power will give the best view of these stunning objects

OCTOBER'S NIGHT SKY

See page [illegible] a key [illegible] chart



IC1396 ▷

Adam Stewart, York
August 2017 & August 2018

HOTSHOTS WINNER
NOVEMBER 2018

November

A transit of Mercury and a lunar occultation of Jupiter are two rarities to relish this month

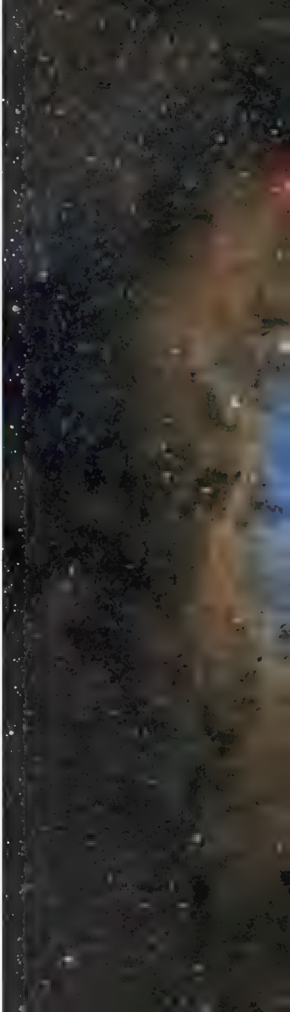
11 NOVEMBER
Transit of Mercury

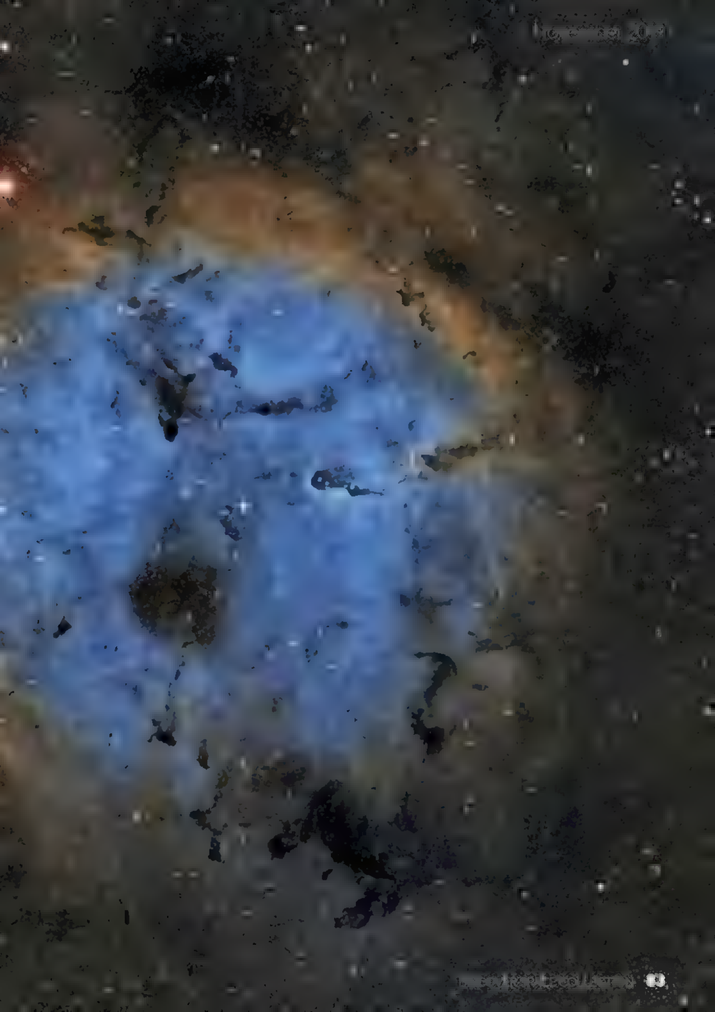
17/18 NOVEMBER
Peak of the Leonid meteor shower, with Moonlight interference

24 NOVEMBER
Moon and Mars appear close in the morning sky

28 NOVEMBER
Daylight lunar occultation of Jupiter

29 NOVEMBER
Venus, Moon, Jupiter and Saturn appear close in the evening sky

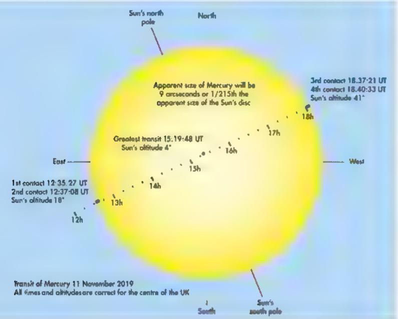




November

MOON PHASES
Key stages in the monthly cycle

FIRST QUARTER 4 Nov | FULL MOON 12 Nov | LAST QUARTER 19 Nov | NEW MOON 26 Nov



VISIBLE PLANETS
Where to spot the planets this month

MERCURY
Transit on 11 November. Visible from 20 November in morning sky. Greatest western elongation on 28 November.

VENUS
Evening planet best seen towards the end of November. Close to Jupiter on 24 November.

MARS
Telescopically poor morning planet. A thin waning crescent Moon close by on 24 November.

JUPITER
Evening planet joined and outshone by Venus on 24 November. Occulted by the Moon in daylight on 28 November.

SATURN
Evening planet slowly engulfed by the twilight. Moon lies near on 2 and 29 November.

URANUS
Well positioned all month. Located in Aries and just possible to see with the naked eye.

NEPTUNE
Well placed during November able to reach highest position, due south, in darkness all month.

The transition zone between the autumn and winter sky is very evident in the hours before midnight during November. The watery constellations of **Pisces**, **Cetus** and **Eridanus** occupy a large area of the sky, but they aren't particularly striking in shape or form.

The most recognisable part of Pisces is the asterism known as the **Circlet** which lies to the west of the constellation and south of the Great Square of Pegasus. One particularly interesting thing to look out for here is the very red fifth-magnitude **19 Piscium** which marks the eastern extremity of the Circlet.

Cetus is the most identifiable of the three water constellations mentioned, thanks to the irregular pentagon shape which is supposed to represent the head of a sea monster. The brightest star in that 'head' is orange giant **Menkar** (Alpha (α) Ceti). The brightest star of Cetus as a whole is **Deneb Kaitos** (Beta (β) Ceti) and this can be found by extending the line made by the eastern side of the Great Square of Pegasus south. Located a little north and around 14.5° east of Deneb Kaitos is **Tau (τ) Ceti**, a mag. +3.5 star 11.9 lightyears away from us, which has been the subject of many science fiction novels. This is well deserved because, innocuous though Tau appears, it's a single star much like the Sun which is known to have at least five planets in orbit around it.

PETE LAWRENCE X 3, ISTOCK X 7, NASA X 4

Celestial hide and seek

The region to the north of the head of Cetus is occupied by **Aries the Ram**. The most prominent shape here is a bent line of stars which starts in the east with **Hamal** (Alpha (α) Arietis). The most interesting thing about Hamal is that, as stars go, it's pretty average. Although this may not sound particularly exciting, it does mean that Hamal is a good reference star against which to compare others.

November 2019 plays host to a rare event known as a **transit of Mercury**. Both of the inferior planets Mercury and Venus, have the capability of passing between Earth and the Sun. When they do so, the planets look like dark silhouettes against the Sun's disc. Transits of Venus are very rare, the next not due to occur

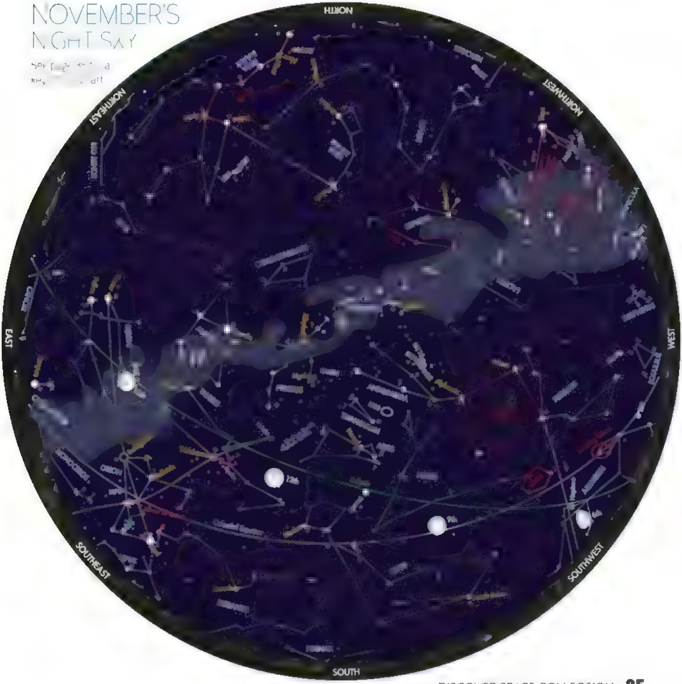
until December 2117. Those of Mercury occur more frequently, but are still infrequent enough to attract a lot of attention. The last occurred on 9 May 2016 and after this one on 11 November the next one isn't due until 13 November 2032.

Lasting around five and a half hours, the transit takes place at a time when the Sun isn't particularly high as seen from the UK, and this will add an extra challenge to observing the event. In addition, from the UK it's not possible to see the whole transit as the Sun will have set by the time Mercury moves off the Sun's disc.

WARNING
Do not look directly at the Sun with the naked eye or any unfiltered optical instruments

As if the transit of Mercury isn't enough to satiate your desire for infrequent astronomical events, a rare **lunar transit of a planet** takes place on 28 November. This will also be a challenging event to observe because it takes place during the hours of daylight as seen from the UK. The planet in question is Jupiter and this will be hidden behind the disc of a 3% lit waxing crescent Moon as the Moon rises around 09:30 UT on 28 November. As the Moon gathers altitude it should become easier to see – although by no means child's play – giving you approximately one hour to prepare for Jupiter's emergence from behind the illuminated lunar crescent.

NOVEMBER'S NIGHT SKY



December

Taurus continues to delight as Orion provides ample hunting ground at the year's end

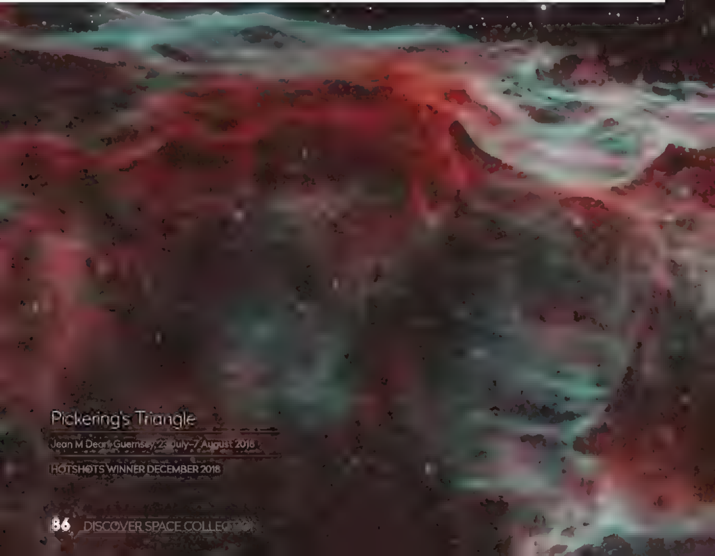
4 DECEMBER
Callisto's shadow transits Jupiter's disc in daylight

11 DECEMBER
Venus and Saturn close in the evening twilight

13-14 DECEMBER
A Moonlit Geminid meteor shower peaks

22-23 DECEMBER
Favourable conditions for the peak of Ursid meteor shower

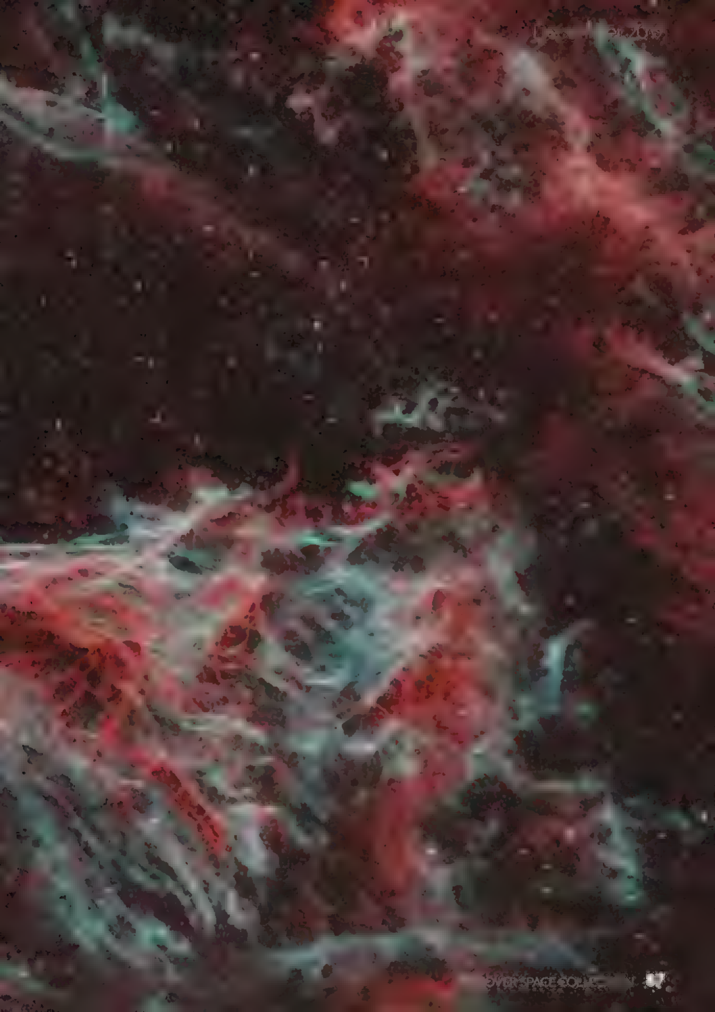
29-30 DECEMBER
Crescent Moon appears close to Venus in the evening sky



Pickering's Triangle

Jean M Dean, Guernsey, 23 July–7 August 2018

HOTSHOTS WINNER DECEMBER 2018



should be very obvious

December

MOON PHASES

Key stages in the monthly cycle

4 Dec

19 Dec

26 Dec

VISIBLE PLANETS

Where to spot the planets this month

Well positioned in the morning sky at the start of December. The planet remains visible until Christmas Day

Spectacular evening object setting three hours after the Sun at the end of December. Close to Saturn on 11 December

Mars is a morning object and telescopically rather poor, showing a tiny 4 arcsecond disc

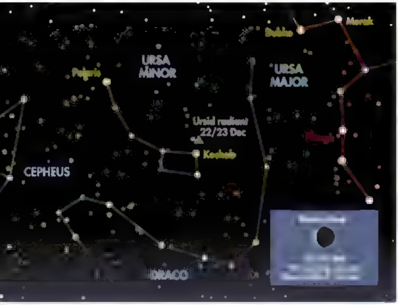
Evening planet close to the Sun. Located near Venus and Saturn at the start of December

Evening planet low in the southwest after sunset

Evening planet well positioned in Aries

Currently close to Phi (φ) Aquar. Best placed in early December

The magnificent constellation **Orion** starts to dominate the sky during December (turn to page 48 to find out more about its mysteries). The Belt of Orion is a useful signpost to other stars – follow its line southeast to arrive at brilliant Sirius, the brightest nighttime star of them all. In the other direction lies the distinctive orange Aldebaran, the brightest star in **Taurus the Bull** (read more about the secrets hidden in Taurus on page 90).



Below Orion is a small pattern of stars representing **Lepus the Hare**, a constellation resembling the sign for infinity with ears! Lepus contains several interesting objects, including the red variable star R Leporis, known as Hind's Crimson Star. Find it by extending the line from Arneb (Alpha (α)) through Mu (μ) Leporis and extending it for approximately four-fifths that distance again.

A similar star-hopping technique can be used to locate **M79**, an eighth-magnitude globular cluster south of the infinity pattern. Extend a line from Arneb through Nihal (Beta (β) Leporis) for the same distance again to find it, although its low altitude makes it something of a challenge from the UK.

A loyal hound and a Christmas tree

The region to the west of Lepus appears rather sparsely occupied, being home to the meandering form of **Eridanus the River**, the longest constellation in the night sky. From the UK we only get to see the northern part of the river; those who live further south can see the bright star Achernar (Alpha (α) Eridani) which marks the southern end of Eridanus.

There's a ghostly reflection nebula close to the star Cursa (Beta (β) Eridani) known as **IC 2118, the Witch Head Nebula**. It gets its informal name because in long-exposure photographs it has the appearance of a witch's face in profile. The nebula has a low surface

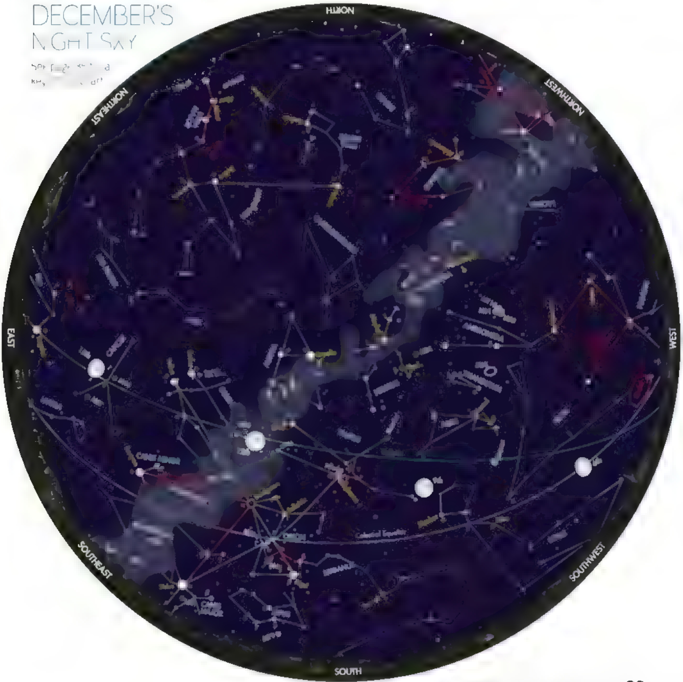
brightness and is best suited to astrophotography.

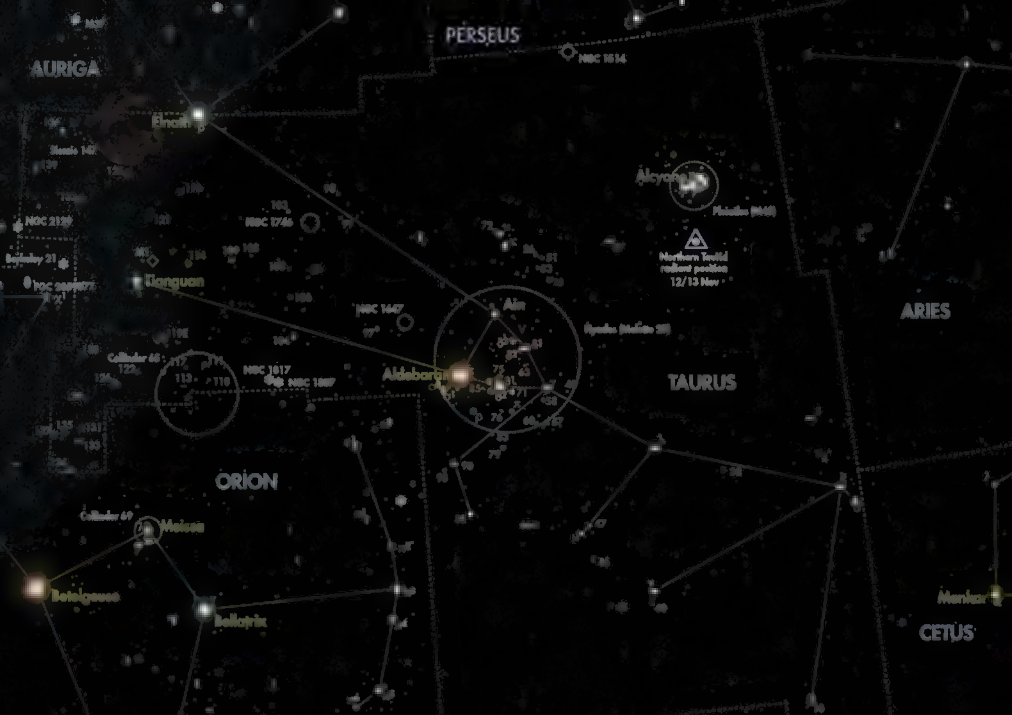
The stars to the west of Lepus belong to the lovely constellation **Canis Major the Great Dog**, running up the sky towards its master, Orion. The Dog's head is represented by a right-angled triangle which can be seen to the east of Sirius (Alpha (α) Canis Majoris). One front leg is marked by Mirzam (Beta (β) Canis Majoris) to the west of Sirius. The rear legs and tail are quite distinctive, although from the UK they never get particularly high above the southern horizon.

North of Canis Major is **Monoceros the Unicorn**. This is a large but ill-defined constellation full of interesting objects. Beta (β) Monocerotis, for example, is a lovely telescopic triple star. Then there are the clusters M50 which lies 4.3° north-northeast of Canis Major's nose and M48 which lies slightly to the east of Monoceros in neighbouring Hydra. Both are binocular objects.

Further north there is **NGC 2244**, an open cluster which lies in the centre of the visually dim but photogenic Rosette Nebula. Slightly north of this region and on the tip of the unicorn's horn is a complex region of sky which includes the Cone Nebula, Fox Fur Nebula and a rather fitting object for December, the **Christmas Tree Cluster**, NGC 2264.

DECEMBER'S NIGHT SKY





PERSEUS
AURIGA
NGC 1514
Alcyone
Pleiades (M45)
Northern Taurid
radiant position
12/13 Nov
NGC 2129
NGC 1746
Elgnath
ARIES
NGC 1647
Aldebaran
NGC 1817
NGC 1807
TAURUS
Collinder 65
ORION
Collinder 69
Meissa
Betelgeuse
Bellatrix
CETUS

AUTUMN: Taurus

Taurus the Bull is an iconic constellation of autumn and winter. Some suggest it may even be represented in the 17,000-year-old cave paintings in Lascaux, France. In Greek mythology, Taurus was the form Zeus took to abduct the beautiful Phoenician princess Europa.

The constellation contains two large and obvious naked-eye clusters: the V-shaped Hyades and the Pleiades, also known as the Seven Sisters. At a distance of 151 lightyears, the Hyades is the closest open cluster to the Sun. The main V-shape is large, with arms 4° in length. Orange giant Aldebaran (Alpha (α) Tauri) sits at the end of the southern arm of the 'V' but isn't part of the cluster, lying approximately half as far at 65 lightyears. The Hyades is old, around 625 million years. The star Theta (θ) Tauri sits halfway along the bottom arm of the V, a naked-eye optical double.

The Pleiades are more distant at 444 lightyears. With an age of around 100 million years, this is a young cluster full of hot, bright, blue stars. The brightest star here is Alcyone (Eta (η) Tauri). The cluster contains at least 1,000 stars within its core radius of eight lightyears, and has a tidal radius of 43 lightyears. It is estimated that one quarter of its members are brown dwarfs, objects of insufficient mass for nuclear fusion to begin.

The bull's eye and beyond

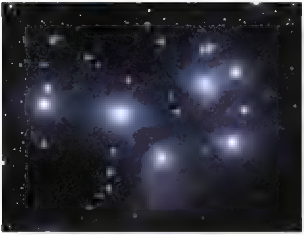
Long-exposure photographs show the Pleiades full of blue reflection nebulosity, the result of the cluster stars passing through an unconnected dust cloud in the Milky Way. Under dark skies, some of this nebulosity can be glimpsed through a telescope.

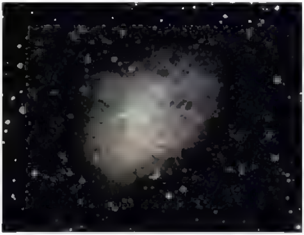
The Hyades and Pleiades are large and bright enough to be part of the 'structure' of Taurus, the Pleiades marking the creature's shoulder blade, the Hyades its face. Aldebaran represents one eye, with Ain (Epsilon (ε) Tauri) the other.

Extending the arms of the Hyades' V east brings you to the stars marking the Bull's horn tips. The upper and brighter one is Elnath (Beta (β) Tauri). Originally known as Gamma (γ) Aurigae, it's often depicted connected to the neighbouring constellation of Auriga the Charioteer.

The southern horn tip is marked by Tianguan (Zeta (ζ) Tauri), a name of Chinese origin which means 'celestial gate'. Tianguan is useful for locating M1, the Crab Nebula, a supernova remnant from a star explosion witnessed from Earth in 1054 AD, an event bright enough to be seen in daylight for 23 days. A telescope is needed to see what's left of the star and it can be underwhelming, typically little more than a faint grey smudge. Astrophotography brings out more detail, revealing a delicate network of glowing filaments surrounding an interior glow. An extreme object known as the Crab Pulsar sits at the heart of the Crab Nebula. Discovered in 1968, this was the first pulsar to be linked to a supernova remnant. The explosion produced an incredibly dense neutron star, 20km in diameter, which spins and 'pulses' at 30 times a second.

Two low-rate meteor showers have their radiants in Taurus: the Southern Taurids, active from 10 September until 20 November, and the Northern Taurids, active from 20 October until 10 December. Both showers have maximum ZHRs of five meteors per hour.





ALL PICTURES: PETE LAWRENCE

BBC Sky at Night MAGAZINE

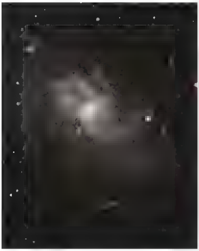
HOTSHOTS

Best of 2018

Each month of this Yearbook starts with a winning photo from our monthly Hotshots competition. Now see some of the other superb images we received in 2018

Moonset over the Angel ▷

David [illegible], taken [illegible] October 2017

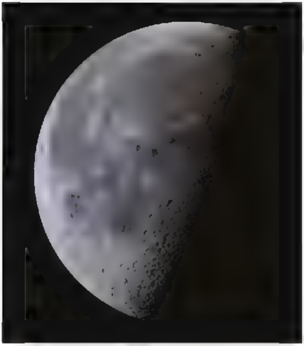


△ The Triangulum Galaxy M33

Gary Stone, Peterborough, taken 18 November 2017

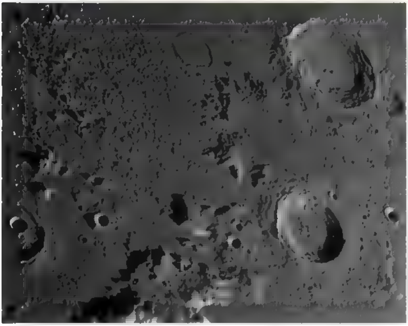
Moon montage ▷

David Ettie, Tyne and Wear
taken 10 November 2017



▽ The Pleiades

Jason Wiseman, Devon
taken 17 December 2017



△ Aurora

Gu Williams, Ylläs, Finland, taken 19 January 2018

◁ Craters Aristoteles & Eudoxus

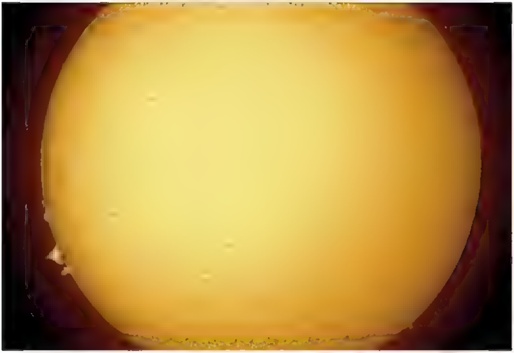
Avani Soares, Canoas, Brazil, taken 25 December 2017

▷ Slaley Skyscape

Gary Pescod, Slaley Forest, Northumberland National Park, taken on 13 February 2018

◁ The Horsehead Nebula

Simon Todd, Haywards Heath, taken 9, 11 & 15 February 2018

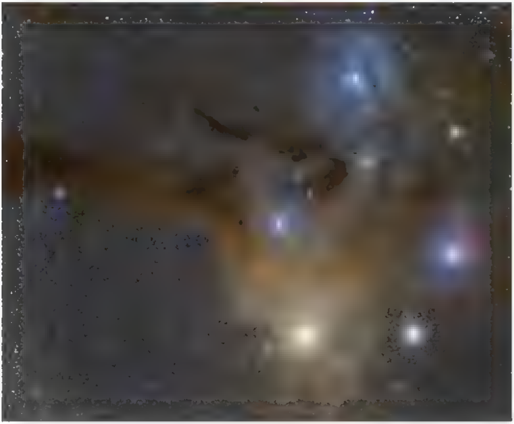


◁ The Sun

David Pickles
Northants
taken 14 April 2018

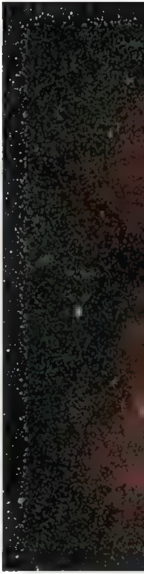
▽ Antares region

Rafael Compassi, Presidente Lucena
Brazil, taken 23 April 2018



The Carina Nebula ▷

Marc Richter, Namibia, taken 1[illegible] May 2018

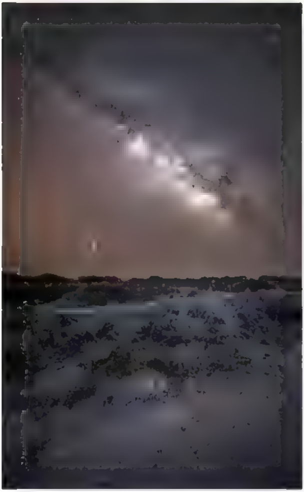


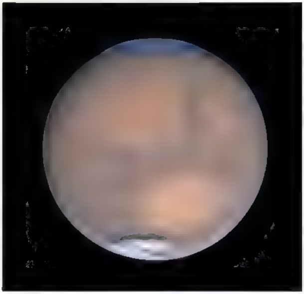
The Milky Way ▷

Mark Pelleymounter, Kimmeridge Bay, Dorset, taken 20 May 2018

◁ The Trifid Nebula

Luís Fernando Palmegiani, Padre Bernardo, Brazil, taken 12 July 2018





△ Mars

Aggelos E[illegible], Nicosia, Cyprus, taken 4 August 2018

◁ ISS, Mars and Milky Way

Chris Pomeroy, Cyprus, taken 3 August 2018

The Dumbbell Nebula

Georges Chassaigne, Fregenal de la Sierra, [illegible]

Project 1: Spot the planets

Turn sky detective and see if you can pick out the unique defining characteristics of every planet in our Solar System

The planets are a constant source of wonderment, each with its own defining qualities. This project highlights some of these characteristics and challenges you to identify two aspects of each planet's appearance. One will be a moderately easy characteristic and the other harder. To help locate your targets, you can find summaries of the planets' positions in the month by month guide in this Yearbook.

We'll start with inner planet **Mercury**, the smallest of the main planets, with a diameter of 4,879km. Its average distance from the Sun is 57.9 million km and it takes 88 days to complete each orbit. It's not the easiest planet to spot, oscillating between morning and evening sky but never straying too far from the Sun.

Our easy characteristic for Mercury is just to spot the planet in either the evening or morning twilight. Trivial as this seems, it's surprising how many amateur astronomers have never seen it! During 2019 it's best seen in the evening sky late in February into early March, and in the morning sky in mid-August and late November into early December.

For Mercury's hard characteristic, once you've located it we want you to look at it with a telescope. Mercury is an inferior planet, meaning its orbit is smaller than Earth's. The angle between Mercury, the Sun and Earth means it can show a phase. Spot this and you'll have observed the hard characteristic. On 11 November 2019, Mercury transits the Sun (see page 84), giving you the opportunity to catch it at a rare 'new' phase.

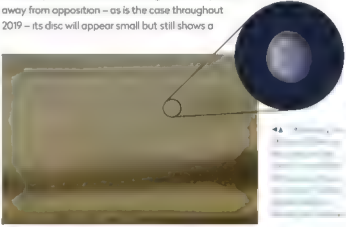
WARNING
Take great care if attempting to view Mercury through a telescope if the Sun is above the horizon

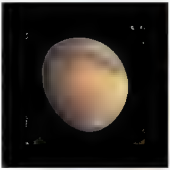
Phase quest

Like Mercury, **Venus** is also an inferior planet, appearing to flit back and forth either side of the Sun. However, its larger orbit means its apparent separation can place it in much darker skies further out on the edge of twilight. Its thick dense atmosphere reflects sunlight well and it's the brightest of the main planets visible from Earth. Like Mercury, Venus shows phases. For the easy characteristic we simply want you to observe Venus through a telescope and note its phase.

The Venusian globe can look uninteresting through the eyepiece, its bright atmosphere often appearing uniform in appearance. But this isn't true and once your observing eye kicks in you should start seeing subtle shading differences. For our hard characteristic we want you to observe and record these shadings.

The next observable planet is **Mars**. This can be frustrating because it only presents a decent-sized disc a few months either side of opposition. This is the time when surface detail is easiest to see. The next opposition occurs on 13 October 2020. For our easy characteristic we want you to look at Mars through a telescope. When away from opposition – as is the case throughout 2019 – its disc will appear small but still shows a





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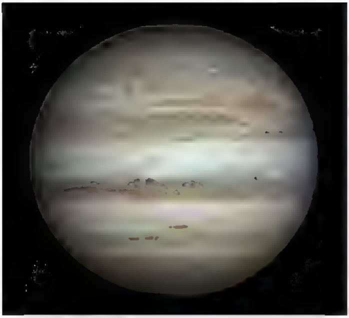
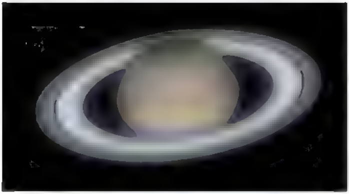
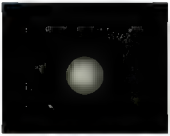
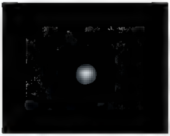








characteristic salmon-pink colour. Despite having a larger (superior) orbit to Earth, Mars can show phases. For a bonus observation, see if you can spot this phase.

The hard characteristic is easy near opposition, but will be tricky during 2019. We want you to try to see surface detail. Mars has dark features – exposed rock – and light deserts. It also has bright polar caps. If you can spot anything like this during 2019 you're doing well!

Jupiter is a gas giant with a complex atmosphere segregated into bands and zones by the planet's fast rotation. Our easy characteristic requires you to spot several features related to the planet's equator. Its fast-rotating gaseous globe appears flattened into an oval bulging at the equator. Two wide, dark bands encircle the globe, running parallel to the equator. These are the north equatorial belt (NEB) and south equatorial belt (SEB). Finally, take note of the four largest 'Galilean' moons of Jupiter. Io, Europa, Ganymede and Callisto orbit close to the planet's equatorial plane and appear as bright dots more or less in line with the equator.

For Jupiter's hard characteristic we want you to try to observe the persistent storm known as the Great Red Spot (GRS). This is always present, nestled into the southern edge of the SEB. However, its visibility isn't guaranteed because you'll need to catch the planet at a time when the GRS is on the side facing Earth.

Track the ice giants

Saturn's easy characteristic is satisfyingly predictable. We want you to observe and note the ring system. The hard challenge also concerns the rings. For this we want you to try to spot the Cassini Division, a narrow gap running between the outer A-ring and the inner B-Ring. It's only 4,700km wide and requires good atmospheric stability to be able to record it all the way around.

The ice giants **Uranus** and **Neptune** are trickier in as much as they are so distant that they don't offer much in the way of detail that amateurs can see. In both cases the easy characteristic is to note each planet has a disc and to record its colour. For Uranus's hard characteristic we want you to see whether you can detect any banding or shading on the planet's disc. Unlike the other hard characteristics, this one is particularly tough and will require a large telescope.

A large aperture will help with Neptune too, because here we want you to try to spot its largest moon, Triton. Although Neptune is a very distant world, Triton does stand out surprisingly well through larger scopes.

How did you do?

How difficult did you find locating all the planets? How did you fare with observing their harder characteristics?

Project 2: Cracks in the Moon

Best seen under low light conditions, these lines in the Moon's surface are a fascinating feature. Use our guide to see how many you can find

The Moon is a captivating target for amateur astronomers and even a small telescope can reveal its craters, mountains, valleys and lava-filled seas. But the Moon's surface also has a lot of cracks. Many are just a few kilometres wide but tens or hundreds of kilometres long. Some are isolated, while others appear connected in delicate criss-crossing networks. Oblique lighting can make these cracks appear very dramatic and it's an intriguing exercise to trace their paths across the Moon's surface.

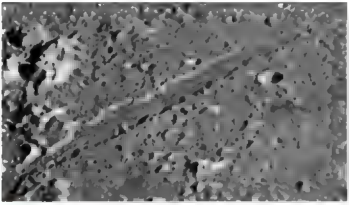
A lunar crack is known as a rille, from the German word for 'groove'. The Latinised form is rima for a single rille or rimae for multiple rilles. There are three different types of rilles: straight, sinuous and arcuate.

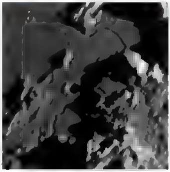
Straight rilles often look like roads from above. A graben is an example of a straight rille, a region of lunar surface which has dropped between two parallel fault lines. A classic example of a graben is the **Vallis Alpes**. Although too large to be considered a rille in its own right, Vallis Alpes does have a narrow crack that runs down the middle of it. With a width of around 0.7km, this is quite challenging to see and requires really steady conditions and at least 250mm of aperture. It's a little easier with high-resolution imaging, but still far from a pushover.

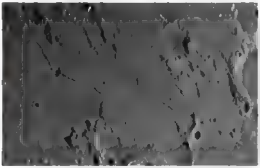
Another excellent example of a straight rille can be seen running from the western rim of Hesiodus through into Palus Epidemiarum in a northeast to southwest direction. Called **Rima Hesiodus**, this really does look like a road crossing the lunar lava. It measures 3km in width and is around 300km in length.

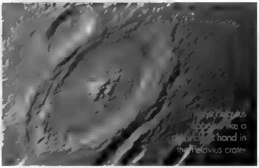
Straight, sinuous and arcuate

The region south of Mare Serenitatis also has some excellent examples of straight rilles. **Rima Ariadaeus** runs between Mare Vaporum and Mare Tranquillitatis. This is shorter than Rima Hesiodus at 220km long, but wider at 7km. It also has the classic road-like appearance of a graben. It ends close to another famous rille, known as **Rima Hyginus**. This is again









... hand in the Petavius crater

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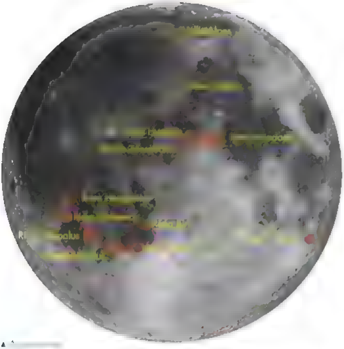
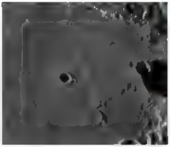
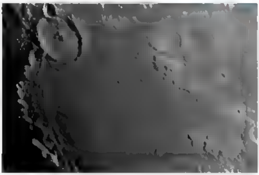






220km in length, but narrower with a width of 4km. It's also rather odd, apparently changing direction when it encounters the flat floored 10km crater Hyginus which lies at the centre of the rille's run. Large apertures or high-resolution imaging show Rima Hyginus to be quite unlike a graben, but rather formed from a multitude of tiny craterlets along its length. One theory is that this was a lava tube which collapsed to form the rille, the craterlets appearing at the same time as the collapse.

A relatively short hop of 140km southwest from Hyginus brings you to 27km **Triesnecker.** A complex and delicate set of interconnecting cracks appear to run roughly north south to the east of this crater. The Rimae Triesnecker complex is a glorious sight when the sun is low in the lunar sky. Their width is around 2km.

The early waxing crescent or early waning gibbous are ideal phases for seeing another famous straight rille known as **Rima Petavius.** This 2km-wide, 80km-long crack runs from the central mountain complex of the 177km crater Petavius towards the southwest rim. This makes it look like a giant clock hand. Larger instruments should be able to make out a continuation of the crack running north from the mountain complex toward the northern rim.

Sinuous rilles form when lava runs beneath the lunar surface, creating a structure called a lava tube. As time goes by and everything cools, the empty tube may collapse, revealing a meandering river-like rille. The most famous example requires at least 200mm of aperture to spot, along with good seeing. Known as **Rima Hadley,** this lies in a small area of lava to the east of Palus Putredinus, which itself is located to the southeast of 83km Archimedes. Rima Hadley is 2.5km wide and meanders in smooth curves for approximately 80km. The 6km crater Hadley C sits more or less at its centre. The Apollo 15 mission landed close to a prominent northern bend in the rille and sent back images which showed Rima Hadley to be a gently curving depression approximately 300m deep.

Another difficult to observe set of sinuous rilles is located north-northeast of 111km Gassendi, itself a crater filled with straight rilles known as **Rimae Gassendi. Rimae Herigonius** are a set of 1km-wide sinuous rilles which run to the west of 15km Herigonius, towards the eastern rim of lava-filled 119km Letronne. A smaller example can be found to the west of the famous Straight Wall fault, Rupes Recta. **Rima Birt** is a 1.5km-wide sinuous rill that runs for 50km. A 300mm scope is required to see it convincingly.

The final type of rille is an arcuate rille. These are curving rilles most commonly found running parallel to the edge of large circular seas. One of the best examples of arcuate rilles is **Rimae Hippalus.** These are wide rilles which appear to run parallel to one another concentrically with the Humorum basin. A smaller example of arcuate rilles can be found inside the rim of the 98km **Pitatus** which is located on the southern shore of Mare Nubium. A large aperture will show a set of 1km rilles running concentrically around the edge of the crater's floor.

How did you do?

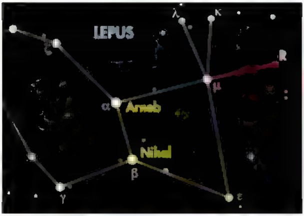
How many of these cracks did you manage to identify and did you successfully image any?

Project 3: Seeing red

Test your star-hopping skills and see whether you can track down our selection of seasonal red beauties

In modern times, we can locate thousands of celestial objects at the touch of a button. But there's nothing quite like finding stuff manually. For this challenge, we're using star hopping to find some understated objects of astronomic beauty: red stars.

Many stars are described as red. The red supergiant **Betelgeuse** (Alpha (α) Orionis) is a good example, but may disappoint when you realise that it doesn't actually look red. To the uninitiated, Betelgeuse seems to have hardly any colour at all. It's only when you move your gaze between Betelgeuse and **Rigel** (Beta (β) Orionis) that you realise that the colour of Betelgeuse does indeed lean toward the red end of the spectrum. However, rather than being pure red, Betelgeuse has an orange hue. This begs the question: are there any truly red stars? The answer is an unsatisfying 'nearly'. A star's colour reflects its photospheric or 'surface' temperature. Higher temperatures shift a star's peak output toward the blue end of the spectrum. These stars look white. Cooler stars have emission peaks in the yellow-red part



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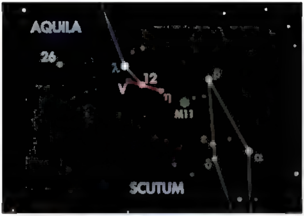
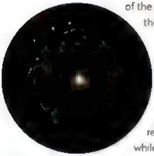


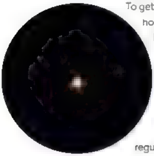


of the spectrum and our eyes cope better with these, seeing them as orange.

One way to quantify a star's redness is to calculate its B-V index, derived by determining the star's apparent magnitude through a blue (B) filter and a visual (V) filter. Red stars have a positive B-V index; the more positive the value, the redder the star. Our Sun's B-V index is +0.66 while that of Betelgeuse is +1.85.

The variable **R Leporis**, or Hind's Crimson Star, varies between magnitudes +5.5 to +11.7 over a period of 427 days. Its redness is most intense when dimmest, its B-V reaching an impressive +5.7. Through the eyepiece R Leporis has a truly beautiful deep orange hue. It was this that caused the astronomer John Hind to describe the star as looking "like a drop of blood on a black field". The B-V decreases to +3.5 when R Leporis is brightest, but this too is quite orange.

On red alert



To get you seeing red and honing those star hopping skills, we've picked a couple of high B-V stars from each season, starting with R Leporis. This is easily found by extending a line from Arneb (Alpha (α) Leporis) through Mu (μ) Leporis for 80% that distance again – an easy star hop so long as you can recognise Lepus!

Our second winter choice is the semi-regular variable **RY Monocerotis**. Draw a line from Sirius (Alpha (α) Canis Majoris) through Theta (θ) Canis Majoris, extending the line for the same distance again. RY Monocerotis sits 1° east southeast of this position. Use a low-power eyepiece and the star should be easy to find, thanks to its colour. RY Monocerotis exhibits variation in brightness between magnitudes +7.5 and +9.2 and has an impressive peak B-V of +4.38.

The spring brings new offerings and our pick is **SS Virginis**. This is located in the Bowl of Virgo. Imagine the line between Zaniah (Eta (η) Virginis) and Vindemiatrix (Epsilon (ε) Virginis). SS Virginis is located one-eighth the way along this line, starting at Zaniah. This is another semi-regular variable, swinging between magnitudes +6.0 and +9.6. Its B-V is +3.86.

Next up, **Y Canum Venaticorum** is easy to find. Draw a line from Cor Caroli (Alpha (α) Canum Venaticorum) and Chara (Beta (β) Canum Venaticorum). Turning 90° to head north-northeast towards the Plough for the same distance again brings you right to it. This is a bright and deep orange beauty. Its magnitude varies from +4.9 to +7.3, with an average B-V of +2.54. Y Canum Venaticorum is also known as La Superba, a name bestowed by 19th-century astronomer Angelo Secchi in appreciation of the star's beautiful colour.

Our first summer selection is mag. +7.6 **T Lyrae**, with an impressively high B-V of +5.10. Locate it midway between the double star Zeta (ζ) Lyrae and Kappa (κ) Lyrae. Next is the semi-regular variable **V Aquilae**, which varies from +6.6 to +8.4. This has a B-V of +4.00 and is easy to locate. Simply extend the line from Eta (η) Scuti through 12 Aquilae for 60 per cent as far again.

Finally, our autumn spots. **UU Aurigae** is a semi-regular variable with a peak magnitude of +5.5 and a B-V of +3.10. Find it by extending the line from Hassaleh (Iota (ι) Aurigae) through Theta (θ) Aurigae for half as much again. **Y Tauri** has a magnitude range of +6.5 to +9.2 and a B-V of +3.44. This is another easy find, located midway between Zeta (ζ) Tauri and Chi-1 (χ^1) Orionis.

How did you do?
Did you track down all of the red targets we featured? Which did you think was the reddest?

How to

Collimate your binoculars

Bring your binoculars back to life with **Stephen Tonkin**'s step-by-step guide to correcting misalignment

The increasing availability of inexpensive astronomical binoculars has opened this side of our hobby to tens of thousands of people who would otherwise have been priced out of it. But with that have come some compromises, one of which is that low-cost binoculars can easily lose collimation.

Collimation, as far as binoculars are concerned, means that the images from the two optical tubes must merge within very tight tolerances. The night sky is very demanding of optical systems, so a slight misalignment that you may not notice in daylight can become especially apparent under the stars. If your binoculars are badly out of collimation they'll give a double image which is, at best, very annoying. However, even if collimation is only slightly outside acceptable tolerances, your brain will attempt to compensate for it, putting strain on the muscles that move your eyes, which can lead to headaches or nausea.

If your binoculars arrive out of collimation or if they're still under guarantee, you should return them to the vendor to be remedied, because the measures described here will immediately invalidate any warranty. If the guarantee has expired, you may wish to have them collimated by a professional repairer, but for many inexpensive binoculars this will cost more than the price of replacing them. In this case, you have nothing to lose by attempting the job yourself.

It takes specialist equipment and a lot of skill to perform a full collimation, so what we'll do here is what's known as a 'conditional alignment', where we align the optical tubes with each other in order to get a single image, but we won't attempt to align them with the hinge as well. As a result, they'll only be in good alignment for the interpupillary distance at which you align them: this is the 'condition' in conditional alignment.

Aligning the prisms

The typical cause of Porro-prism binoculars losing collimation is being dropped or receiving a knock that shifts one of the prisms. In the most common form of inexpensive binoculars, each prism is held in place with a spring clip that tensions it against a screw that tilts the prism. This arrangement means the prisms are vulnerable to being dislodged by impacts, but it also

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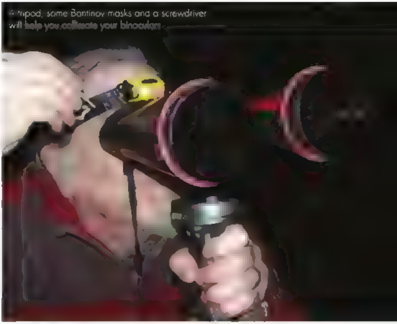


A tripod, some Bahtinov masks and a screwdriver will help you collimate your binoculars

means that you can usually correct the problem by adjusting the tilting screws.

First of all, thoroughly examine your binoculars to make sure that any miscollimation isn't due to external physical damage, such as an objective tube being bent out of alignment. Fixing this kind of defect is beyond

Tools and materials

MATERIALS
Print out the Bahtinov masks on transparency film suitable for your printer. This removes the need to cut out the individual slots. Leave three tabs evenly spaced around each mask to tie down on to your binoculars. Anaglyph glasses are a useful alternative to Bahtinov masks and can be used in daylight.

TOOLS
A head-torch is essential for hands-free illumination of the task. An L-bracket or hinge clamp is essential to hold your binoculars still while you collimate them. Select a small flat-head screwdriver to fit the collimation screws. Use elastic bands or sticky tape to secure the Bahtinov masks to your binoculars.

the scope of this guide. Next, you should test the binoculars under a night sky. To do this, you have to overcome the ability of your eyes and brain to merge images that aren't actually merged.

There are three ways to fool your brain into thinking that the separate images are of different objects, each one offering an increasing level of complexity and precision.

The first and most simple method is to defocus one side of your binoculars. The focused image from the other side should be central in the defocused image.

The second method is to use different-coloured filters, such as 3D anaglyph glasses (although coloured cellophane sweet wrappers will do in an emergency), so that the image from each side is a contrasting colour. You can also use these during daylight to merge the images of, for example, a distant TV antenna.

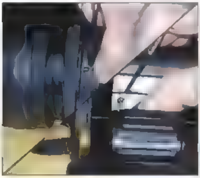
The third and most precise method is to use Bahtinov masks, orientated at right angles to each other. The simplest way to obtain these is to use a mask generator, such as astrojargon.net/maskgenerator.aspx. Note: the website will request the focal length of your objective lens. If you don't know this, assume it's four times the aperture.

If you follow the step-by-step guide below and get the collimation as precise as you can, you'll give your binoculars a new lease of life and be able to enjoy many hours of strain-free observing.

Step by step

Step 1

The first step is to determine whether your binoculars are really out of collimation. Observe a bright star and defocus the right-hand eyepiece. Any displacement of the focused star from the centre of the defocused one is the error you need to correct.



Step 2

It's a good idea to locate the collimation screws in good lighting. They will be small and may be covered by casing and adhesive. Remove material that's covering them. Then choose the correct size of flat-head screwdriver to turn the screw and break any locking adhesive.

Step 3

Even if you don't normally mount your binoculars, you should do so now. Polaris, if you can see it, is a good target for collimation as it doesn't move appreciably. If you choose a terrestrial object, pick one that's at least a kilometre distant.

Step 4

The collimation screw tilts the prism against the tension of the spring clip. Look through both eyepieces, and rotate each screw by no more than one eighth of a turn at a time to see what effect it has on the image, then return the screw to its original position.

Step 5

Make sure that you have set your binoculars to your interpupillary distance (IPD) then, using what you've learned about the action of each collimation screw, merge the images into one, again using no more than one eighth of a turn of the screw each time.

Step 6

When you think you have the images merged, check the IPD again and use the Bahtinov masks or anaglyph glasses to make sure that they're as closely merged as you can get them. Lastly, use them normally and enjoy the new and improved view!

Build a low-cost wooden tripod

Make a sturdy, portable alternative to a solid pier or home observatory with **Mark Parrish**'s DIY guide

Most astronomers would love a permanent observing setup in their garden, and to that end an observatory or a solid pier is often the dream solution. Of course, that's not always possible. What if there are surrounding trees or buildings that mean you need to shift your setup to different parts of your garden to view different parts of the sky? What if you can't make permanent changes to your property?

Whatever limitations you face, the inevitable result is that you are obliged to use a moveable tripod. This brings its own issues. Taking your tripod indoors after each session loses your carefully gained polar alignment, but leaving what can be a very expensive piece of equipment outside could be a big attraction for thieves. That's why we're going to explain how to build an inexpensive, stable tripod that can be left in place or moved around as needed.

The timber you'll need can be readily acquired from a local builders merchant. We chose 'prepared' (planed) timber because it is nicer to handle and looks attractive, but you could use equivalent rough-sawn wood to reduce the cost further. The bolted construction of the leg frames and the use of hinges to join the frames mean you don't need to have any special skills to assemble the main parts. The tripod is immensely strong and has plenty of mass, which helps to provide a very solid platform on which to fix your mount. Our tripod is 1,065mm (3.5ft) tall, but you can alter the design of the central pier; for example, make it taller if you have a long refractor or shorter for a big Newtonian.

We used a dark brown preservative wood stain, but there are many colours available, so you could camouflage your tripod to blend in with the bushes or match other garden furniture and features.

The top of the tripod and the mount fixing consist of a number of hexagonal plywood plates. Luckily, if you can't remember your school geometry lessons, there are downloadable templates available at https://bit.ly/2AQy5fF. It's best to cut them simultaneously so that each ends up the same shape. If you mark one edge of the stack you can realign them easily even if they aren't perfectly symmetrical.

Plating up

Your telescope mount will be bolted to its own removable hexagonal top plate, which fits precisely into the tray-like, fixed top plate on the tripod. This

Tools and materials

TOOLS
Hand saw, jigsaw or chop saw, drill and bits

MATERIALS
Two 8ft lengths of 98x38mm construction timber. Four 8ft lengths of 63x38mm construction timber. 1/8th of a sheet of 18mm plywood or similar, plus a few small offcuts of plywood.

SUNDRIES
Nine M10x150mm coach bolts with nuts and washers. Three pairs of 75mm butt hinges and screws. A few each of 4-inch and 2-inch woodscrews. A pair of M6x60 bolts with wingnuts.

FINISH
Approximately 0.5l of preservative wood stain.

ALL PICTURES: MARK PARRISH

means you can lift off the whole assembly after an observing session and then replace it the following evening, maintaining your polar alignment. We drilled two holes through our top plates and used a couple of small bolts with wingnuts to hold them together once the mount assembly is lifted on, so there is no danger of equipment being knocked off during use. You could also use a G clamp for this purpose

Adapting the removable top plate to suit your particular mount may require a bit of careful measuring and cutting but, having examined a multitude of EQ mounts from various manufacturers, we concluded that you will normally just have to cut a large round hole (around 60mm in diameter) in the upper, thick layer of plywood and a smaller 10mm hole in a thinner layer that is subsequently glued beneath Many manufacturers sell 'pier top adaptors' for just this kind of project, and they are worth investigating if you prefer to keep things simple

If you need a stable, non-permanent, economical base on which to mount your equipment, we hope that you will want to give this project a try. You may have a number of mounts, in which case you could make a separate top plate for each one, so swapping them becomes a cinch. You may even decide to make a couple of tripods, locating them in the optimum areas of your garden for different sections of the sky and moving about during a night's observing

Step by step

Step 1

After carefully marking out the parts, use a saw to cut them to size. You can use the downloadable templates at https://bit ly/2AQy5fF to help you get the angles right. If you have access to a chop saw you could save some time here. Check the similar pieces match

Step 2

Drill the 10mm holes in one example of each part. Use this to transfer markings to the corresponding parts. You can line up the parts with the 'master' on top, then put a bolt in the hole and strike it with a hammer, denting the one below

Step 3

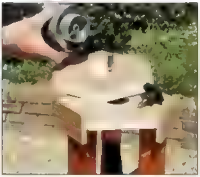
Once all the timber is cut, sand any rough edges and check it all fits together If the holes are tight you can 'waggle' the drill or re-drill them using a 10.5mm bit. Now is a good time to paint the wood with preservative stain

Step 4

Bolt the three triangular leg frames together Each short 'foot' section should be fixed between the two leg struts with long woodscrews once you have aligned the other elements. Fix a pair of hinges to each frame, then join all three frames to form the tripod

Step 5

Mark out the plywood hexagons. Drill a centre hole in each and a second hole near to one corner, then use small bolts or dowels to hold the layers together before cutting – this ensures replica shapes. Screw one fixed top plate to the tripod and add plywood lips



Step 6

Measure your mount. Cut a suitable hole in a removable top plate. Glue a block of hardwood or similar into a notch to form a pin for the alignment screws. Screw a second thin layer of ply (with a central hole for the fixing screw) to the underside

How to

Build a rolling scope platform

You get your setup just how you like it... and then it's time to pack it away again. **Mark Parrish** has the solution, with this simple rolling platform

Our setup atop the completed dolly; the tripod plates should be as close to the wheels as possible

Most medium-sized mounts and telescopes are too heavy and unwieldy to move once they've been assembled, which means setting up and packing away each night can become a slog. There's the numerous journeys back and forth to the garden, for one. Refitting mount heads and weights takes up time when you could be out observing, and rebalancing a telescope can be fiddly work in the dark. It is also all too easy to misplace leads and small parts.

This project, an inexpensive rolling dolly, provides a workaround. Leave your fully assembled setup on top of it and whenever the skies are clear you can simply roll the whole unit into position. If the weather turns against you, you can be back in the warm in next to no time, secure in the knowledge that nothing is left behind.

The timber for the dolly's axles can be readily obtained from a builder's merchant. We chose 'prepared' (planed) 45x45mm timber because it is nice to handle and can be painted to match your other equipment. The plywood parts provide bracing: we made ours from 9mm thick sheet, but you could use a slightly different thickness if you already have some available. The dolly frame needs to be rigid, but as most of the scope's weight is supported close to the wheels it doesn't need to be too heavy. Individual parts are bolted together, allowing you to take the dolly apart for easy storage or transport. Furthermore, the design allows for resizing should you ever decide to upgrade your tripod.

Start by looking at the downloadable plans available at https://bit.ly/2DpJIC7. They show dimensions for our example dolly, and these measurements should suit most small to medium tripods. We have indicated the positions we drilled holes in the bracing plates, but we'd recommend lining up your beams and tripod support plates with your own tripod to determine the best position for these holes before drilling. Ideally, the wheels and jacking points should be as close to the tripod feet as possible.

For wheels, we chose 150mm plastic ones with rubber tyres. These run well on M12 studding axles and they seem to cope with regular gravel drives and garden lawns. Because the speeds involved are low and distances relatively short, pneumatic tyres and

Tools and materials

TOOLS
Handsaw or jigsaw, hacksaw, drill and bits (for 12mm and 8mm bolts), spanners, screwdriver.

MATERIALS
Approximately 3m of 45x45mm construction timber, 1,200x600mm sheet of 9mm plywood, length of suitable timber or rope for the handle.

SUNDRIES
Four 150mm-diameter wheels with rubber tyres, 1m of M12 studding (diameter to suit wheels) with nuts and washers, six M8x75 bolts, 75mm butt hinge, epoxy resin glue, 25mm woodscrews.

FINISH
Preservative wood stain or paint.

ALL PICTURES: MARK PARRISH

proper bearings are not necessary unless you are scaling up the design for a heavyweight mount or you have particularly bumpy ground to cover.

Finessing the design

If your tripod legs have slightly pointed feet, a simple hole drilled in the leg support plate will help locate them. If you have a tubular design, you could make L-shaped corner blocks and screw them into each plate to prevent your tripod from sliding off. Tying your tripod down with straps or bungees is also a good idea, in case you bump against something or have to stop suddenly. The last thing you want is for your setup to pitch forward and crash to the ground.

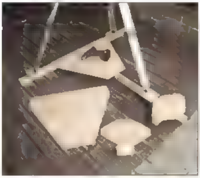
On the front of the dolly is a rigid towing handle. It attaches to the front of the steering mechanism via a hinge, so it can be folded back against the tripod when not in use. You could also use a loop of rope or webbing as a simpler alternative. When you have your dolly in position, screw down the jacks to stop it moving accidentally. Once you are polar aligned, you could also mark the jack positions on the ground to aid repositioning on future nights.

We also found that the bracing plate below the tripod is ideal for holding accessory cases and a power tank, but you could consider customising this area to provide racks and boxes for your accessories and imaging equipment.

Step by step

Step 1

After carefully marking out the parts, use a saw to cut them to size. You can tape multiple plywood parts together and cut in one go so that they match each other. If you have access to a band saw or jigsaw you could save some time here.



Step 2

With your main parts cut, drill holes in the plywood parts first, then line them up with the axles. Place your tripod on top to check size. Mark through the holes to find out where to drill into the axles. Do this, then assemble the timber and plywood parts.

Step 3

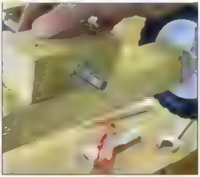
Make the steering 'box'. It's held together with 25mm woodscrews inserted through the plywood plates into the axle and front blocks. A piece of studding provides a pivot. Use Nylock nuts and washers and make sure it turns smoothly but is not wobbly.

Step 4

Cut lengths of studding for the axles using a hacksaw. Allow enough for a nut and washer either side of the wheel, plus about 50mm to be glued inside the wood. File the ends of the studding so that they aren't sharp and the nuts fit on nicely.

Step 5

Check that the wheels spin freely without wobbling. Use epoxy resin to glue each axle in, taking care not to get any glue on the moving parts. If the wheel needs to be removed later on, you should be able to simply undo the outer nut.



Step 6

Once the tripod foot plates and jack blocks are screwed into position, drill through both for the studding. An enlarged hole on the underside gives you room to glue in a captive nut (normal type). Use a Nylock nut (or a wooden disc) to make the upper turning knob.

Glossary

Essential astronomical terms explained

APERTURE
The diameter of a telescope's light-gathering main lens or mirror. The bigger the aperture, the brighter and more detailed the image.

AVERTED VISION
A technique for observing faint objects through a telescope. It involves viewing slightly to the side of the object, allowing its light to fall on an area of the eye more sensitive to light.

BINARY STAR
A system of two stars that orbit a common centre of gravity. The brighter star is classified as the primary, while the dimmer is the secondary.

BLACK HOLE
The collapsed core of a massive star. Its concentration of mass is so dense that nothing, even light, can escape its gravitational pull.

CELESTIAL EQUATOR
A projection of the Earth's equator into space.

CELESTIAL SPHERE
The projection of the night sky on to an imaginary sphere around the Earth. The astronomical coordinates of right ascension and declination are also mapped onto this sphere.

COLLIMATION
The process of aligning the optical elements of a telescope or binoculars.

COMET
A ball of frozen gases, rock and dust that orbits the Sun.

DECLINATION
The celestial equivalent of latitude, this is the distance of a body north or south of the celestial equator, measured in degrees, minutes and seconds. Objects north of the celestial equator have a positive declination, while those south of the celestial equator have a negative declination.

ECLIPTIC
The apparent annual path of the Sun against the background stars.

ELONGATION
The angle in the sky between a planet and the Sun, as seen from Earth. At its greatest elongation (east or west), a planet is – from our perspective – at its farthest apparent distance from the Sun.

EQUINOX
The two times each year – on or near March 21 and September 22 – at which the Sun crosses the celestial equator.

FOCAL LENGTH
The distance between a telescope's main lens or mirror and the point at which an image is brought into focus. You can work out magnification with this number; this is calculated by dividing the focal length of a telescope by that of an eyepiece.

GIBBOUS
When the Moon or other body appears more than half, but less than fully, illuminated (from Latin gibbus, meaning 'hump').

LIBRATION
The apparent tilting or wobble of the Moon as it orbits Earth, allowing 59 per cent of its surface to be seen over a period of time.

LIGHTYEAR
A unit of measurement equal to the distance that light travels in one year – about 5.8 trillion miles.

MAGNITUDE
The brightness of an astronomical body. The lower the number, the brighter the object. Magnitudes brighter than zero are represented with a negative number.

MERIDIAN
An imaginary line circling the Earth from north to south that marks the point at which the Sun is at its highest in the sky.

METEOR
Also called a shooting star, this is a small particle of dust or rock that burns away on entering Earth's atmosphere. A meteor shower is when meteors are observed to radiate at regular intervals and from a particular region in the sky as Earth passes through debris left by a disintegrating comet.

NEBULA
A cloud of interstellar dust and gas, usually lit up by stars inside or nearby.

OCCULTATION
When the Moon or a planet conceals or obscures a more distant planet or star.

OPPOSITION
The position of a superior planet when it's opposite the Sun in the sky.

PHASE
The apparent change in shape of a celestial body as different amounts of its surface are illuminated by the Sun. The Moon displays four main phases: new, first quarter, full and last quarter.

RIGHT ASCENSION
The celestial equivalent of longitude, right ascension is measured in hours, minutes and seconds. The 0h line is measured from the point where the Sun crosses the celestial equator on its apparent path through the sky each year, a point called the vernal equinox.

STAR
A giant ball of hot gas that creates radiation through nuclear fusion. Stars are classified by their spectra (the elements that they absorb) and their temperature. The seven main types, from the hottest to the coolest, are: O, B, A, F, G, K and M.

STAR CLUSTER
A grouping of stars, from a few dozen to a few hundred thousand, bound together by their mutual gravitational attraction.

TRANSIT
The passage of a celestial body across the disk of a larger one, such as Mercury crossing the disk of the Sun or Ganymede's shadow moving across the surface of Jupiter.

UNIVERSAL TIME (UT)
A timescale based on the rotation of the Earth on its axis, UT is measured from midnight at the Greenwich Meridian. In astronomical use, UT replaced Greenwich Mean Time (GMT), which was measured from the Greenwich Meridian at midday on 1 January 1925.

VARIABLE STAR
A star that fluctuates in brightness over time, such as eclipsing binaries like Algol or pulsating stars like the Cepheids.